CASE

harry diamond laboratories

fiscal year 81 laboratory review

u.s. army electronics research and development command

1981 laboratory review

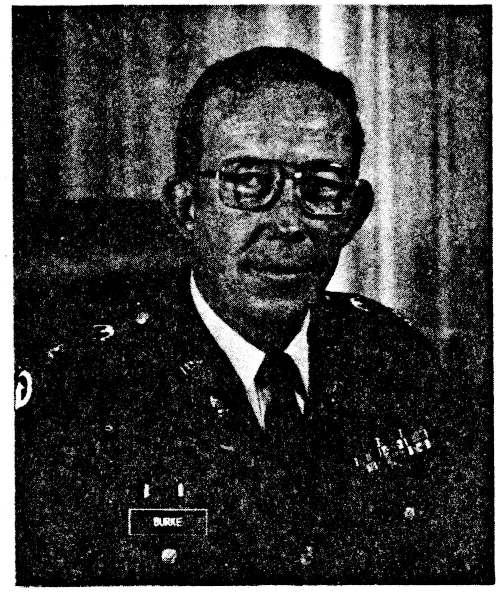
harry diamond laboratories
adelphi, maryland 20783

Distribution limited to U.S. government agencies only.
Other requests for this document must be referred to

Commander
Harry Diamond Laboratories
Attn: DELHD-TA-R
2800 Powder Mill Road
Adelphi, MD 20783

Editorial review, photocomposiition, design, and layout by the Technical Reports Branch, HDL.
Editor: Barbara Collier

The editor thanks Donna Melito, Anna Eller, and Deborah Lehtinen for their invaluable help.



foreword

FY 81 has been a very productive year for the Harry Diamond Laboratories (HDL). The strength of HDL was demonstrated in many ways, particularly in the role of a full-spectrum laboratory in which ideas generated in basic research are moved rapidly through engineering development to industrial production. The technical excellence and productivity of the staff continues strong, as is evident from this report.

Approximately half of HDL's efforts are expended on electronic fuzes. Six HDL-developed fuzes are now in active production. New signal-processing techniques, electronic counter-countermeasures, power supplies, and other technology base areas have been developed. In nuclear weapons effects, primary emphasis went to applying and transferring nuclear hardening technology to a large number of system developers.

Overall, FY 81 was a successful year and we look forward to FY 82.

Allan R Burke

ALLAN R. BURKE
COL, OrdC
Commanding

Contents

Contents (Cont'd)

Contents (Cont'd)

Contents (Cont'd)

Contents (Cont'd)

Contents (Cont'd)

Contents (Cont'd)

Contents (Cont'd)

Contents (Cont'd)

Contents (Cont'd)

chapter 1. executive summary

The Harry Diamond Laboratories (HDL) remains one of the Army's strongest research and development establishments. Covering a diversity of technologies, HDL is a full-spectrum laboratory with expertise in areas from basic research to industrial engineering. Its principal areas of involvement are electronic fuzing, nuclear weapons effects, fluidics, radars, antiradiation missile countermeasures, signal processing, and related technologies. It has initiated programs in several new technologies, such as electronic warfare and sensors for brilliant munitions.

In the electronic fuzing area, HDL has continued to push vigorously to complete engineering development and transition to production of several items. The fuze for the Multiple-Launch Rocket System (MLRS), after completion of the validation phase of development with a 100-percent successful test, entered the maturation phase. The fuze for the Patriot system was put into production, and a new growth program was initiated to give the system the capability to operate in a more adverse environment than was previously specified. First deliveries were made on the M735 fuze for the 8-in. nuclear projectile. The XM749 fuze for the 155-mm nuclear projectile is under vigorous engineering development and has successfully passed preliminary tests.

The nuclear weapons effects program, for which HDL is the Lead Laboratory, has completed several product-improvement programs in electromagnetic pulse (EMP) hardening of Army tactical communications equipment. The technical data packages for hardening of many satellite ground terminals were completed.

New fluidics technologies have not only provided several new capabilities for Army systems, such as tank turret stabilization, but have had important applications for the civilian economy in diverse areas, such as a temperature sensor which can operate up to 3,000° F and which has the potential to save significant energy nationally.

Noteworthy unclassified accomplishments are reported here in related areas, including near-millimeter waves (NMMW), signal processing, acousto-optics, radar technology, and electronic warfare (EW). Productivity in the laboratories has picked up again after major professional personnel cuts in prior years. HDL is contributing to a strong Department of Defense (DoD) posture in many scientific and technical areas of military importance.

Technical Contributions and Highlights

Fuzing

M818 Fuze for Patriot. HDL has completed engineering development of the M818 fuze, which was type classified in Aug. 80. An effort has begun to integrate the government-furnished microprocessor-controlled test equipment into the prime contractor's computer-controlled system.

XM749 Fuze for XM783 155-mm Nuclear Projectile. The XM749 fuze continues in engineering development, under the projectile management of the Armament Research and Development Command (ARRADCOM). The physical configuration and electrical interface are mutually controlled by ARRADCOM, HDL, and the Department of Energy (DOE) laboratories. The first major milestone has been met, with the initial fuze design having been completed and prototype fuzes having been fabricated and tested successfully in gun firing. The results confirm the analysis made to predict electrical and mechanical performance. A telemeter system has been designed and tested, demonstrating a significantly enhanced capability to monitor the severe in-bore gun environment.

XM445 MLRS Fuze. The fuze for the Multiple Launch Rocket System (MLRS) is presently in the maturation phase of the development cycle. Contracts have been awarded to a prime fuze contractor for simultaneous engineering development and low-rate production of the fuze in FY 81. Engineering development fuzes have been delivered to the system's prime contractor (Vought Corporation) for flight testing.

The prime contractor completed 43 test flights of the fuze and rocket at the White Sands Missile Range (WSMR) with a perfect fuze score. The cumulative fuze test result for the validation and maturation phase tests at WSMR is now 93/93. First-article testing will begin in Oct. 81, with the first production lot scheduled for delivery in Jan. 82.

The XM447 fuze, a modified version of the XM445, completed its first development flight phase at WSMR with the German AT2 mine warhead, also with a perfect score (10/10).

Anti-Armor Fuzing. Inductive sensors which detect the presence of armored targets such as tanks and helicopters have been developed for various types of high-explosive multipurpose (HEMP) and self-forging fragment warheads. The fuze-target interaction has been modeled and prototype hardware has been fabricated for field-test demonstrations.

Fuze for Shoulder-Launched Multipurpose Assault Weapon (SMAW). The fuze for this Marine Corps weapon has entered engineering development. During FY 81, a baseline design data package was prepared and used as the basis of a development contract requiring delivery of 600 fuzes.

Surface Proximity Fuze (SPF). The exploratory development program for a surface radar fuze for reentry vehicles was concluded with the fabrication and laboratory evaluation of three units. Preparations are presently underway to modify one unit for differential leakage measurements on the advanced airburst fuze antenna system.

Microstrip Planar Antenna. HDL developed a computer program for the dimensioning of linear series-fed microstrip antenna arrays and applied it successfully to the design of several planar arrays with specified beam angles and sidelobe patterns.

Millimeter Wave Antennas. HDL designed and fabricated the Army's first monolithic linear microstrip antenna array for 94 GHz; it exhibits a 3° beam width and sidelobes of less than −10 dB.

Lead Dioxide Research. The in-house evaluation of latex-bonded lead-dioxide electrode material (developed under contract with Ray-O-Vac Div. of ESB, Inc.) showed that this material has a higher potential energy density than the standard electroplated material, but has a lower power density, particularly at low temperature. It may, therefore, be used as a substitute material for applications with long-life re-

quirements at mid to low current. The evaluation of the storage characteristics of this material is continuing.

Reserve Batteries for Small-Caliber Ordnance. The development was completed of the 1200-rps spinner with the electrical readout capability necessary to test activation and discharge characteristics of batteries for small-caliber fuzing systems.

New Electrochemical Systems. Thermal batteries using lithium alloy/iron disulfide electrochemical systems were built, tested, and compared to similar batteries based on the normally used calcium/calcium-chromate electrochemistry. The various advantages of each system in terms of materials processing, fabrication, and discharge performance with respect to HDL application requirements are being evaluated.

Development of PS506 Battery for Unattended Expendable Jammer (UEJ). The contract with Honeywell Power Sources Center to demonstrate the feasibility of a lithium-based reserve power supply for the UEJ is nearing successful completion. Full 10-cell battery stacks were fabricated and successfully tested under a variety of temperature and spin conditions. The electrochemical system being used for this battery is lithium/thionyl chloride-lithium aluminum chloride/graphite.

Chaff-Resistant Fuzing. HDL has been engaged in evaluating the chaff threat to fuzing through a combination of field data collection experiments, data reduction, and the development of computer models for chaff based on these data.

Air-Encounter Simulation. As part of target-fuze end-game lethality assessments, computer models for near-field backscatter signatures of aircraft targets have been developed in cooperation with the Air Force and several allied countries.

Anti-Ballistic Missile Study. Air-defense fuzing studies against a high-velocity ballistic missile have been undertaken to assess the performance of positional prediction based on Kalman filtering.

Monopulse Fuze System. The feasibility of a monopulse radar implementation for a medium-size air-defense missile has been established. Accurate location of targets and an integral fuze-on-jam capability have been demonstrated.

Division Air-Defense Gun (DIVADS). HDL has completed an evaluation of the performance of two DIVAD proximity fuze candidates. This concluded an extensive three-year evaluation program by HDL in support of the DIVAD Project Manager.

Digital Fuzing Techniques. Real-time synthesis of complex modulation waveforms and corresponding IF correlation waveforms by means of practical, inexpensive digital technology has been combined with a novel system concept, yielding a fuzing system with enhanced electronic countermeasure immunity. A system tailored to the conventional artillery requirement was fabricated which demonstrated exceptional performance.

Roland Fuze Support. HDL continued to support the Roland Program Manager in a wide variety of areas, including design studies, hardware implementation, and end-game simulation for performance assessment and hardware assessment of an improved Roland fuze.

Ground Clutter at Very Low Altitude. HDL has completed initial investigations into the nature of terrain clutter at very low altitudes. Radar signatures were obtained which are representative of those for an air-target radar fuze engaging low-flying targets or helicopters hovering in treetops.

Optical Fuzing. HDL continued to perform applied research on optical fuzing, with main emphasis on defining a baseline all-weather air-target missile optical fuze. The approach is to use very short pulses to reduce the aerosol backscatter and allow pulse-shape discrimination. Target-return data were obtained to determine target pulse shapes and firing points.

Aerosol data obtained in conventional and experimental obscurant smokes and natural clouds were evaluated, and computer-processing techniques to obtain system response to measured aerosol distributions were developed. Electronic circuitry for pulse-width discrimination was designed and breadboarded. Work also continued on an optical fuze sensor that is being considered for an anti-radiation projectile (ARP); much of the electronics was breadboarded and the optics were designed. Aerosol calculations were carried out for this system to assure that it is resistant to prefunctioning in clouds or smoke.

Electrostatic Air-Target Fuze. This year work in the area of electrostatic fuzing showed that a simple signal processor could reliably recognize target signatures and reject non-target outputs in sensor responses obtained from live gun firings. Sensor responses to a hovering UH1 helicopter were found to have unexpectedly low amplitudes. Plans now are to perform measurements of helicopter charge.

Inductive Remote Set. In FY 81, HDL researchers increased the data transfer rate of the inductive remote set system and demonstrated in the lab that setting could be achieved after muzzle exit for a tank gun system using a muzzle extender of composite material.

Inductive setting was chosen by ARRADCOM as the Army standard for the development of the XM762 electronic time fuze.

Inductive-Influence Fuze. Air-gun tests showed that greater standoff could be achieved to optimize the performance of shaped-charge warheads.

Nuclear Weapons Effects. As the lead laboratory for nuclear weapons effects (NWE) research and testing at the U.S. Army Materiel Development and Readiness Command (DARCOM), HDL is heavily engaged in system vulnerability assessment and hardening for DARCOM Project/Program Managers (PM's) and commands and the Defense Nuclear Agency (DNA); technology development and application associated with nuclear weapons electromagnetic pulse (EMP), system-generated EMP (SGEMP), transient-radiation effects (TRE), and blast and thermal effects; research, development, and operation of EMP, TRE, thermal-radiation, and blast simulators; NWE information dissemination; and tactical nuclear warfare studies.

In FY 81, the NWE program continued to emphasize vulnerability assessment and hardening studies of both tactical and strategic communications, command, and control (C^3) systems and their associated mobile electric power (MEP) units. High-altitude EMP (HEMP) studies and current-injection tests were carried out on the XM2 tracked armored vehicle. In an effort to harden a major single-channel radio system, a value-engineering proposal resulted in replacing an internally mounted EMP fix with an externally mounted EMP fix. This action resulted in a saving of $2.5 million by eliminating the need for a contractor team required to install the internal fix. A hardness assurance/hardness maintenance (HA/HM) tester has been designed, built, and tested at HDL to support a major multichannel radio EMP product-improvement program (PIP). The tester is designed to be used by regular production and maintenance personnel. Plans were accomplished for a manufacturing methods and technology (MMT) program effort to develop a more general HA/HM EMP tester that will support all hardened multichannel radio systems. The Communications Electronics Command (CECOM) is scheduled to deploy this unit in FY 82/83. Work has continued on final hardened fix designs for a second major single-channel radio system and for a high-capacity multichannel radio system, both of which are being product improved to withstand the HEMP threat. Certification tests have been conducted on the final fix designs for the multichannel radio systems. TRE verification experiments have been conducted on suggested fixes for Army communication systems, including their MEP units. TRE assessments of the TACFIRE and Missile Minder systems have been completed and draft reports generated.

Continued progress has been made in the development of data on the susceptibility of semiconductor components to the effects of EMP and radiation. Detailed plans have been developed to produce a two-dimensional version of the HDL one-dimensional EMP burnout

code. In the TRE area, measurement efforts on large-scale integration (LSI) devices have continued to expand and include total dose, dose-rate induced upset, latch-up, and permanent failure measurements on dynamic random-access memories (RAM's), microprocessors, and peripheral support devices. Specific efforts have been conducted on the 8086 (16-bit) microprocessor and the 4116 (16k) RAM.

Also in FY 81, HDL provided chairmanship of the configuration control subpanel of the panel on logistic support of nuclear hardened systems.

Assessment and Hardening for EMP. HDL is engaged in a funded program to provide HEMP protection packages for the priority satellite earth terminals which are part of the Defense Satellite Communications System (DSCS). These terminals are located worldwide (e.g., Ft. Detrich, Md., and Wahiawa, Hawaii) and include the AN/FSC-78 heavy terminals and the AN/GSC-39 medium terminals. The HDL efforts are called the Satellite Terminal EMP Protection (STEP) program. The program calls for technical data packages and management data packages for hardening selected satellite terminals. TRW has been selected as the main contractor. The program is in a test-verification phase, using the Generic Verification Facility (GVF) at the HDL Woodbridge Research Facility. On-site current-injection tests by HDL are being planned which will use a portable tester. An EMP hardening practices handbook has been issued for comment and is being prepared for final publication. The STEP program responds to the requirements of the Army Communication Command (ACC), the Department of Army (DA) organization responsible for terminal survivability. Coordination with the individual MIL DEP's is in progress to implement protection measures developed under this program.

Several tactical source-region experiments have been conducted at the AURORA facility, modeling the source-region response of long cables by using a slow-wave structure approach with significant success. Electron-beam experiments were conducted that investigated the use of the AURORA facility as a source-region simulation tool.

A new HEMP environment code has been developed which incorporates the best features of several past codes plus new information. This new code is a significant step forward in EMP environment prediction.

Assessment and Hardening for TRE. An experimental evaluation was completed of the neutron susceptibility of the universal military standard voltage regulator used in conjunction with the Army 3-, 5-, and 10-kW MEP engine generator sets. Using the results of previous analysis, a joint experiment with the Mobility Equipment Research and Development Command (MERADCOM) was conducted addressing this neutron problem. This experiment, which covered the military operating temperature range, was documented in a report that was provided to MERADCOM.

Additionally, circuits in specific Army communication equipment (e.g., modem, multiplexer, and line repeater) that were previously identified in the TRE studies as possibly susceptible were evaluated experimentally, and appropriate reports written. These reports confirm system TRE analysis and will become the basis for initiation of TRE PIP efforts. Radiation-effect studies on hardening fiber optics, materials, and cables are continuing, along with research into hardening fiber optics to blast and thermal effects. Additionally, a forward-looking infrared (FLIR) lens was found to be undamaged by high thermal fluences when appropriately mounted.

Assessment and Hardening for All Effects. HDL has continued to support the Single-Channel Ground and Airborne Radio System (SINCGARS) PM's NWE survivability program through a DNA-funded effort. The Nuclear Weapons Effects Support Team (NEST), a DARCOM-funded effort, is now providing technical and managerial support to over 60 separate individual materiel developments that have nuclear survivability requirements. Every DARCOM major subordinate command is represented on this list, which includes systems such as MLRS, remotely piloted vehicle (RPV), Firefinder (FF), and DIVAD. This year, an HDL study of the tactical nuclear European battlefield revealed that a large number of command and control systems in forward areas

would be exposed to a strong SGEMP threat environment, even if they survived the other more familiar nuclear battlefield threats (tissue dose, blast, and thermal illumination). The study combined current and future estimates of Soviet weapons capability and attack philosophies with realistic deployments of U.S. Army command and control systems inside the divisional sector.

Detailed studies of the radiation-system interaction have been carried out on selected systems; quantitative measures of the SGEMP threat have demonstrated the importance of interior electromagnetic shielding to the nuclear survivability of systems.

The physical security of 300 Defense Communication System (DCS) sites was surveyed to determine their unique physical problems. The site design practices to solve these site security problems have been included in a draft of a Military Standard for physical security of DCS assets, which has received initial review and is being published for community review.

The Hardened Tactical Shelter (HATS) project produced on contract the first Model T version of HATS. This shelter is ballistically hardened and provides a survivable replacement for the current S-250 and S-280 electronics equipment shelters. The shelters are being designed to protect electronics in C^3 systems and in surveillance and target acquisition systems. The designs will also provide protection against nuclear fallout, biological, and chemical (NBC) effects when fitted with appropriate ancillary equipment. Nuclear-effects and military standard testing is in progress. The first S-280 Model T shelters have been successfully tested on the MILL RACE high-explosive nuclear blast simulation test at and above design levels. DARCOM and the Training and Doctrine Command (TRADOC) are preparing a requirement document for a Model T HAT Shelter which calls for limited production in the following years. This Model T design has evolved from hardening technology concepts developed within the research programs at HDL and the Ballistic Research Laboratory (BRL).

TRE Technology Development. Efforts have continued to automate the techniques for electrically simulating radiation damage in metal-oxide semiconductor (MOS) gate insulators for use in the hardness-assurance part of the life cycle, and an MMT program has been planned to assist the introduction of this effort in the manufacturing process.

HDL has been supporting the Army Ballistic Missile Defense (BMD) PM in the NWE area. A major output in this year has been the generation of an EMP environments handbook for the PM.

HDL has assisted the Ballistic Missile Defense Systems Command by organizing a team of Army laboratory personnel to advise and assist the Low Altitude Defense System Project in designing for nuclear survivability and in obtaining NWE data.

HDL developed advanced concepts for an SREMP simulator, which included efforts to develop a new pulse-power source (CAMELOT) to drive the radiation portion of the simulator.

Additional supporting efforts were performed in nuclear environments definition, simulator evaluation, contractor proposal evaluation, and design and evaluation of experiments to obtain basic data. HDL also participated in formulating a joint BMD technology program with DNA.

NWE Simulation. All the NWE simulators have been extensively used during this fiscal year; many strategic and tactical systems developers (e.g., Hellfire and Stinger) were supported in their NWE efforts. Additional, new fiber-optic links were provided for the instrumentation van (IVAN) used with the Army EMP Simulator Operation (AESOP) and the Repetitive EMP Simulator (REPS). The high-voltage trigger system for AESOP has been rebuilt. Efforts were initiated to refurbish the CW Facility at Woodbridge and eventually make it mobile.

The state of the art in fiber optics has been advanced with the completion of a prototype radiation-hardened analog fiber-optic data link. Developed for DNA's Nuclear Weapons Effects Test Program, the link is designed to carry radiation-response signals from a test object electrically isolated in a cold evacuated radia-

tion tank to a distant recording station. The functional versatility and electrical performance of this prototype is unmatched in any other fiber-optic link on the commercial market or in the government inventory.

Tactical Nuclear Studies. In previous years, a methodology has been developed to relate the battlefield effectiveness of tactical units to the value of enhanced NWE survivability. The methodology serves to assist in pinpointing candidate systems for future vulnerability and hardening assessment studies. Short studies in the intelligence, surveillance, and target-acquisition (ISTA) and air-defense areas have been conducted and draft reports produced. The capability to model the low-yield tactical nuclear threat has been introduced into the methodology this year.

The CONDUCT II C^3 computer simulation model of the Blue force structure operating in conventional and nonconventional environments has been used to support planning by the Army and by the Electronics Research and Development Command (ERADCOM). The model contains a data base which defines (by organization) the command, control, communications, and intelligence (C^3I) systems available to HQ, U.S. Army Corps. Message flow diagrams with functions (tasks) and tables showing times to complete tasks in specific military units and operations have been developed for different initial conditions. Baseline analysis and an electronic warfare (EW) evaluation have been completed of the combat electronic warfare intelligence (CEWI) battalion and target-acquisition battery systems in the 1980 timeframe. Several deficiencies in the use of the ERADCOM-built CEWI/EW systems have been identified and changes suggested to remedy these deficiencies. CEWI and field-artillery timelines have been determined for conventional and nuclear missions. Using these timelines, the effectiveness of joint CEWI and field-artillery missions has been determined.

Fluidics. As DARCOM's Lead Laboratory for Fluidic Technology, HDL continues to provide a focal point for research and development work in this field, not only in the Army, but throughout DoD and other government agencies.

Significant accomplishments in laminar fluidic components have led to a fluidic/electric rate gyroscope that can replace conventional gyroscopes in a number of applications. The heart of this fluidic component is a laminar jet angular rate sensor (LJARS) with a multistage laminar proportional amplifier (LPA) preamplifier. The complete fluidic rate gyro also contains an electrically powered pump to supply air to the fluidic circuit and a transducer to convert the pressure output signal into an electrical one.

One application for the fluidic rate gyro, being sponsored by the U.S. Army Tank Automotive Command, is being developed for a product-improvement program for the Army's M1 tank. The fluidic gyro would be part of the tank's gun-stabilization system. This project is a direct outgrowth of HDL's 6.2 gun-stabilization project that culminated in a technology demonstration on an M48A5 tank in Apr. 79, and HDL's more recent progress on subcomponent development.

HDL is currently conducting a project to develop a three-axis, fluidic rate gyro for missile systems that will be reliable, inexpensive, and immune to electromagnetic interference (EMI) and lightning effects. This effort is being coordinated with a similar effort for Naval applications.

HDL has developed a fluidic capillary pyrometer (which will operate at temperatures as high as 1,000° to 3,000° F) for closed-loop automatic temperature control of a rotary hearth forging furnace. This device significantly increases the quality of forgings and decreases cost through accurate temperature control. The pyrometer has been installed at the government-owned, company-operated Army Ammunition Plant at Scranton, Pa., where its low cost and efficiency have greatly impressed the management staff at the plant.

Surveillance and Target Acquisition. The new HDL program in radar technology was a natural outgrowth of HDL's many years of involvement in foreign and special-purpose radars. A task

was initiated to develop the technology of multistatic battlefield surveillance and target-acquisition radars. Such radars are felt to be necessary for defense against attack by anti-radiation missiles.

A joint DARPA/ERADCOM program is underway to exploit the multistatic radar concept for alerting and cueing ground-target surveillance as well as air-target surveillance.

An advanced ground surveillance radar (AGSR) is being adapted for testing the passive bistatic alerting and cueing concept. The AGSR is intended to support the next generation of ground-based battlefield surveillance radar networks.

Devices and Technology. In FY 81 HDL demonstrated the feasibility of a series-pile-configuration lithium reserve battery for artillery-delivered equipment (in this case, for use as a power source for the unattended expendable jammer [UEJ]).

The G-76 hand-cranked generator was type classified last year and entered initial production this year. Another area of application for the G-76, as a power source for current and projected fuze setters for nuclear projectiles, was validated; production quantities were ordered.

Acousto-Optic Signal Processing. HDL has developed the one-dimensional time-integrating correlator with performance characteristics far surpassing other correlator implementations. In addition, this structure has been miniaturized, using new optical techniques, so that small fieldable versions are practical. A two-dimensional implementation of the time-integrating correlator has been constructed for performing rapid ambiguity transforms. A three-dimensional version of the time-integrating correlator is currently in the conceptual phase.

Very rapid spectrum analysis using acousto-optic Bragg cells and specially constructed detector arrays has been achieved. Quasi-two-dimensional outputs of frequency versus time with narrow time windows have been achieved. In addition, coherent detection techniques have been developed which decrease the time uncertainty within that window. This allows for instantaneous measurements of both time and frequency characteristics of narrow pulses.

An acousto-optic implementation of the Cepstrum processor has been achieved. This processor provides the processing gain of a correlator while maintaining the cw interference immunity of a Fourier transform system.

The development of these devices is a considerable success in the acousto-optic signal-processing area and was the basis for an Army R&D Achievement Award.

Bulk Microwave Acoustic Delay Lines. HDL-patented zinc oxide (ZnO) series-transducer array delay lines have been qualified for use in the following programs:

- the Army's XM749 155-mm nuclear proximity fuze
- the joint USAF/Navy prototype for the airborne self-protection jammer (ASPJ)

These delay lines are also being seriously considered for inclusion in the latest USAF AWACS configuration.

The use of ZnO delay lines in these programs was made possible by the advances in ZnO technology that resulted from an HDL-sponsored MMT program with Westinghouse. This program, which combined ZnO research efforts at HDL and at Westinghouse, led to improvements in ZnO processing that made it possible to produce microwave delay lines having higher insertion loss and greater uniformity, with higher process yield and hence lower cost. Process yield has been improved from 10 to 50 percent or greater, and the resulting devices have improved bandwidth and reliability.

Penetration of Obscurants

NMMW Mobile Measurement Facility. An NMMW mobile measurement facility (MMF) has been developed by HDL to obtain basic data on propagation and target/background characteristics. The NMMW/MMF was designed and built for HDL by the Georgia Institute of Technology Engineering Experiment Station.

During Jan. and Feb. 81, the HDL staff measured transmission and backscatter in falling snow at the SNOW-ONE tests conducted by the U.S. Army Cold Regions Research and Engineering Laboratory. Attenuation coefficients and snow mass concentrations were correlated at all three frequencies of operation: 96, 140, and 225 GHz. During a 9-in. snowfall, measured attenuation coefficients were largest at 225 GHz and least at 96 GHz. Backscatter cross sections per unit volume for falling snow were measured to be between 1 and 7×10^{-5} m^2/m^3 at 96 GHz for water-equivalent snow mass concentrations between 0.1 and 0.6 gm/m^3.

The NMMW/MMF consists of two semitrailers that contain transmitters and receivers at 96, 140, and 225 GHz. One trailer is termed the "transceiver van" and contains high-power, pulsed transmitters operating at the three frequencies. This van also has three heterodyne receivers employing the latest NMMW technology for backscatter measurements from targets or hydrometeorites.

The second trailer, termed the "receiver van," contains three video receivers for measurement of direct transmission and bistatic reflectivities. Data collected at the receiver van are automatically transmitted to the transceiver van for processing and recording. All transmitters and receivers have separate 61-cm diameter Cassegrain antennas whose heights, orientation in azimuth and elevation, and polarizations are adjustable.

NMMW Gyromonotron. HDL, in a collaborative effort with the Naval Research Laboratory (NRL), has built and operated a gyromonotron. This source of high-power NMMW radiation is a tube based on the cyclotron resonance maser principle, in which electrons gyrating at the cyclotron frequency in an applied magnetic field impart some of their energy to the electromagnetic wave in an rf cavity. The HDL-NRL tube, by operating at the second harmonic, can produce 238-GHz radiation with an applied field of 45 kG from a superconducting magnet. Radiation with a peak power of about 50 W was observed at a magnetic field of about 45 kG and a power of about 200 W at a magnetic field of about 46 kG. Frequency measurements with Fabry-Perot interferometers built at HDL indicate that the former is second-harmonic radiation at 238 GHz with a bandwidth of a few megahertz and the latter is first-harmonic radiation at about 120 GHz. Although both these radiations and the values of magnetic field at which they occur are consistent with theory, the output power of the 238-GHz radiation is much lower than the 1.4 kW predicted for this tube. It is believed that changes in the rf structure will increase the output power toward the predicted value.

NMMW Antennas. The Army's first monolithic conformal linear phased-array microstrip antenna has been fabricated at HDL. Designed for 94 GHz, the array consists of 28 rectangular microstrip elements etched from five-mil Teflon substrate using standard printed-circuit technology. Measured results indicate a three-degree beam width, with sidelobes of greater than −10 dB. The antenna was designed using an interactive computer code developed at HDL to help study microstrip antennas for use at microwave to NMMW frequencies. With refinements added to this code, it is anticipated that improved antenna designs at 94 GHz will be possible.

Diffraction Electronics. A tunable, highly coherent source of NMMW radiation, new to the western world, has been developed and tested this year at HDL. This device, the orotron (a name originating from its use of an open resonator), consists of a ribbon-beam-producing electron gun and a metallic diffraction grating enclosed in the open resonator. The orotron has been operated on four different modes and was tuned continuously on a single mode from 53 to 75 GHz. Interesting features of the orotron are that the output power is highly monochromatic, and the device can produce sharp, 100-ns pulses at a high repetition rate by the use of low-voltage signals applied to the grating. Other properties of the device that may make it particularly attractive for military applications are that it can be made into a portable, efficient, intermediate power (cw or pulsed) source of NMMW radiation, which can penetrate fog and smoke.

Experimental and theoretical studies that will contribute toward improved NMMW

orotrons are continuing at HDL. Recent advances in orotron theory at HDL suggest that a more dense beam should allow an orotron to produce several hundred watts of cw or pulsed power at efficiencies comparable to those of gyrotrons (15 percent or better). Beams of these densities can be produced with present technology in a focused magnetic field by shaped, permanent magnets, where the field would serve to converge and guide the beam across the grating.

Electronic and Signals Warfare

Anti-Radiation Missile Countermeasures Program. The Anti-Radiation Missile Countermeasures (ARM-CM) program is a 6.3A-funded technology base program to develop effective means of reducing the vulnerability of Army ground-based and airborne emitters to attack by enemy ARM systems. Since the Army was selected as the lead service to coordinate the tri-service ARM-CM efforts, HDL develops and directs the development of computer models of threat ARM's, friendly emitters (e.g., radars and communications systems), and ARM-CM systems, so that the effectiveness of ARM attacks may be determined. To evaluate the accuracy of these simulations, HDL develops and directs the development (by contractors and other government agencies) of prototype ARM-CM systems and the instrumentation systems needed to field test ARM-CM system effectiveness. To improve the coordination among the services, HDL hosts the Tri-Service ARM-CM Symposium and coordinates the meetings between the intelligence community and the ARM-CM hardware and computer simulation developers. The ARM-CM program also funds the U.S. members of the NATO ARM-CM Working Group.

Artillery-Delivered Expendable Communication Jammer. The expendable jammer is being developed by HDL under the sponsorship of the U.S. Army Signals Warfare Laboratory (SWL). The program objectives are to design, develop, and field qualify a low-cost gun-rugged expendable communication jammer which can be ejected one at a time from the 155-mm projectile during its flight trajectory. During FY 81, while the jammer was in advanced development, HDL demonstrated this unique linear cargo-ejection technique by successfully gun firing "full-up" jammers.

Anti-radiation Projectile Sensor. An advanced development program has been initiated of a sensor for a guided 8-in. projectile that would detect enemy emitters, identify them, and provide guidance information so that the projectile could home in on the target and kill it. A special fuze would also be required. The program started as a joint one with the Naval Weapons Center at China Lake, which has experience with ARM's, and HDL, which has applicable expertise in high-g microelectronics.

Materiel Accomplishments

M732 Proximity Fuze. Over 1.5 million M732 fuzes have been delivered to stockpile. Procurement is being managed by the Armament Materiel Readiness Command (ARRCOM). HDL provides technical support in product improvement, stockpile reliability, and production problem areas. Technical support efforts underway within HDL include assessing the compatibility of the fuze booster with cast TNT in projectiles, redesign of the turning capsule/sleeve interface, assessing the compatibility of the fuze with rocket-assisted projectiles, improving low-zone safety and arming (S&A) reliability, and product-improvement efforts to lower production costs.

M818 Fuze for Patriot Missile. HDL has met its commitment to the accelerated Patriot program by delivering, on schedule, the high-speed automated fuze testers to the Raytheon Corporation. These fuze-level and missile-level testers were designed at HDL and are being used in the final acceptance tests of the first production fuzes. A contract to procure the first production quantity of fuzes was awarded to the Bendix Corporation; the first fuze delivery was made in July of this year. Fuzes have been delivered in time to meet program requirements. The first Patriot missile with an M818 fuze is expected to be completed in FY 82.

M735 Fuze/M38 Setter for 8-in. Nuclear Projectile. On the first production contract with Motorola, first-article acceptance tests were

completed in the second quarter of FY 81, as scheduled. Fuzes are being delivered at a rate that meets the needs of the Project Manager for Nuclear Munitions. A second production contract was awarded to Motorola in Jul. 81. Production will continue through FY 85. The M38 fuze setter, for setting in-flight timing data into the M735 fuze, is being procured in an FY 80 contract with Motorola, Inc. Delivery of the first units was made in Jun. 81, on schedule. Production will continue throughout FY 82.

G-76 Generator. First-article sample tests are currently being conducted before production to deliver quantities of the lightweight, highly efficient, hand-cranked G-76 generator to PM Army Tactical Communication System (ATACS) and PM Nuclear Munitions (NUC) for deployment.

M817 Fuze. A contract for the fifth buy of the M817 fuze was signed in the third quarter of FY 81. Current plans are to transfer this program to MICOM in early FY 82.

M724/M36 Electronic Time (ET) Fuze System. The M724 ET fuze and M36 setter were developed to exploit electronic technology in order to supplement a declining mechanical time (MT) fuze production base. Contracts for constructing and exercising high-rate M724 production facilities were let in Aug. 79. A Congressional review of MT versus ET cost effectiveness in FY 81 led to a DA directive to revitalize the M577 MT production base and lay away the M724 ET system as a backup to shortfalls in M577 production. Production quantities were accordingly reduced to the minimum requirements for prove-out of the initial production facility (IPF), and layaway is to be completed during 1982. Following layaway, an engineering program is planned which is intended to prevent obsolescence of the fuze, setter, and IPF before fielding of a second-generation ET fuze, the XM762, being developed by ARRADCOM.

M734 Multioption Fuze. Over 100,000 M734 fuzes have been produced and delivered to the Milan Army Ammunition Plant, Tenn., for loading and assembly onto M720 60-mm mortars for the Lightweight Company Mortar System (LWCMS). Ballistic lot acceptance testing has shown the performance to be slightly below the requirements of the material need document, but the quality was sufficient to obtain approval for conditional release of material for issue to the troops. The maximum production rate of approximately 25,000 per month is presently limited by amplifier die bonding of the existing amplifier configuration and by shield can/amplifier assembly problems. Value-engineering and product-improved amplifier designs are being evaluated. If these designs are accepted, an amplifier production rate capability of at least 50,000 per month should result.

Technical Achievements Leading to Dollar Savings

Redesign of FITS. The plan to test the XM818 fuze after installation in the Patriot missile required the purchase of seven fuze integrated test sets (FITS's). Each FITS consists of one stand-alone Army factory acceptance tester (AFAT), plus a PM460 interface chassis, since the FITS is used with a PM460 missile test set to test the XM818. The concept of a simplified FITS tester using a smaller AFAT without stand-alone test capability was proposed and implemented. The number of circuit boards in the AFAT was reduced from 48 to 16, and the cost was reduced from $300K to $120K per unit. Total savings for seven units, after subtracting engineering costs, was $1.1 million.

Redesign of Subassembly Tester. An automatic subassembly tester is used in conjunction with the Patriot fuze. It includes fixtures to test five printed-circuit assemblies to locate defective assemblies. A decision was made to test the hybrid microcircuits that make up the bulk of the receiver circuitry and then test the complete receiver, rather than the receiver subassemblies. Although the fixtures to test the subassemblies had already been designed, the cost associated with the fabrication was deleted from the Patriot IPF contract, as was the cost associated with the preparation of the calibration procedures, manuals, maintenance procedures, etc. This decision resulted in a cost savings of $25K.

Redesign of Setback Washer for M734. Alinabal, under contract to HDL for the fabrication of assemblies for use in the production of the M734 turbine alternator, recommended a modification in the fabrication process that would change the design of the setback washer from a separate part, assembled with adhesive, to an integral washer. The decision to accept the change in the subassembly resulted in a total cost reduction of $56K, half of which was retained by the U.S. Government.

New EMP Hardening Technique. Through engineering and design changes a new EMP hardening technique will be used on an Army tactical radio system. This new technique allows for cost savings significant enough to harden 50 percent more of the Army's inventory than previously anticipated.

Noteworthy Technical Management Actions

Microelectronics Facility. In Mar. 80, military construction was completed for a mezzanine of 4,000 ft² over the HDL machine shop in the Research and Engineering Support Building. HDL management committed this space for a hybrid microelectronics fabrication facility. Between Mar. 80 and Mar. 81, this area was equipped with modern hybrid circuit fabrication equipment equivalent to facilities used in private industry. The HDL facility is dedicated to validating the producibility of HDL hybrid circuit designs. In Apr. 81, the facility received its first assignment. It successfully aided in the settlement of a contractual dispute involving the M734 hybrid amplifier.

Program on High-Powered Microwave Effects. HDL established a new program initiative in high-powered microwave effects on military systems. This program is intended to determine the feasibility of development and the military effectiveness of tactical high-powered microwave weapon systems. Program plans have been prepared, personnel assigned, and funding established or identified for this new initiative.

Technical Recruitment. HDL management initiated an aggressive recruiting program for engineers and scientists to counter the large number of retirements this year and those expected in the future. Mass advertising in newspapers and trade journals and streamlined hiring procedures were instituted.

Improvements to Computing Facility and Systems. The Management Information Systems Office has enhanced the capabilities of the central computer facility with hardware augmentation and new operating system software. The central computing complex includes an IBM 370/168 Attached Processor system operating under the control of the MVS-SP1 operating system.

As of 30 Sept. 81, over 1,200 users processed over 1,000 timesharing sessions and 1,100 batch jobs each day. The current hardware will be augmented by an IBM 370/168 multiprocessor computer. This augmentation, currently being installed, will double the processing capacity of the computer center.

Management Information Systems Office support for administration functions was concentrated on maintenance and improvement of existing data bases. Significant new applications were developed, including

- a General Ledger data-base system for processing general accounting data for the HDL Finance and Accounting Office;
- a Budget 1088 data-base system for analysis, review, and automated reporting of historical payroll data;
- a records holding area locator data base for management and control of documents stored in the records holding area; and
- an SWL financial management system—modified versions of the HDL financial accounting systems, used by the HDL Finance and Accounting Office in support of SWL.

Several new applications have been implemented or enhanced for ERADCOM HQ. New standard systems installed were

- Electronic Warfare Integrated Reprogramming (EWIR) and
- Technical Data/Configuration Management System (TD/CMS).

Realignment of Technical Resources. Following the DA decision to terminate the M724 fuze procurement after the FY 80 buy, which decreased the workload in electronic time fuzing within HDL, management decided to eliminate the electronic timing branch and transfer the technical staff to a fuze development branch. This action had two advantages:

- it produced savings by the elimination of one branch office, and
- it promoted more efficient use of technical personnel by increasing the size of the remaining branch to a viable level to handle new development projects.

A management decision was taken to administratively combine the group working on microelectronics research, development, and fabrication with that working on radiation effects on microelectronics physics. This action was taken in order to develop a better understanding of the impact of higher density electronics on the radiation hardness of military systems, by the concentration of a sufficient number of physicists and process engineers to address this growing area of concern to DoD.

Administrative Highlights

Reorganization. Although no major reorganizations of HDL were implemented during FY 81 (see Figure 1, organization chart), several internal reorganizations were accomplished under the RESHAPE concept to increase productivity and improve resource utilization. The three areas affected by reorganization were the Logistics Management Office, the Procurement Office, and the Facilities Engineering Office.

The Logistics Management Office was reorganized as a result of a Command Equipment Management Program Review (CEMPR) and Command Supply Discipline Program (CSDP) review. This action was implemented to facilitate work and supply-document flow and to more effectively maintain the property book accountability system within the supply support function. The reorganization involved the

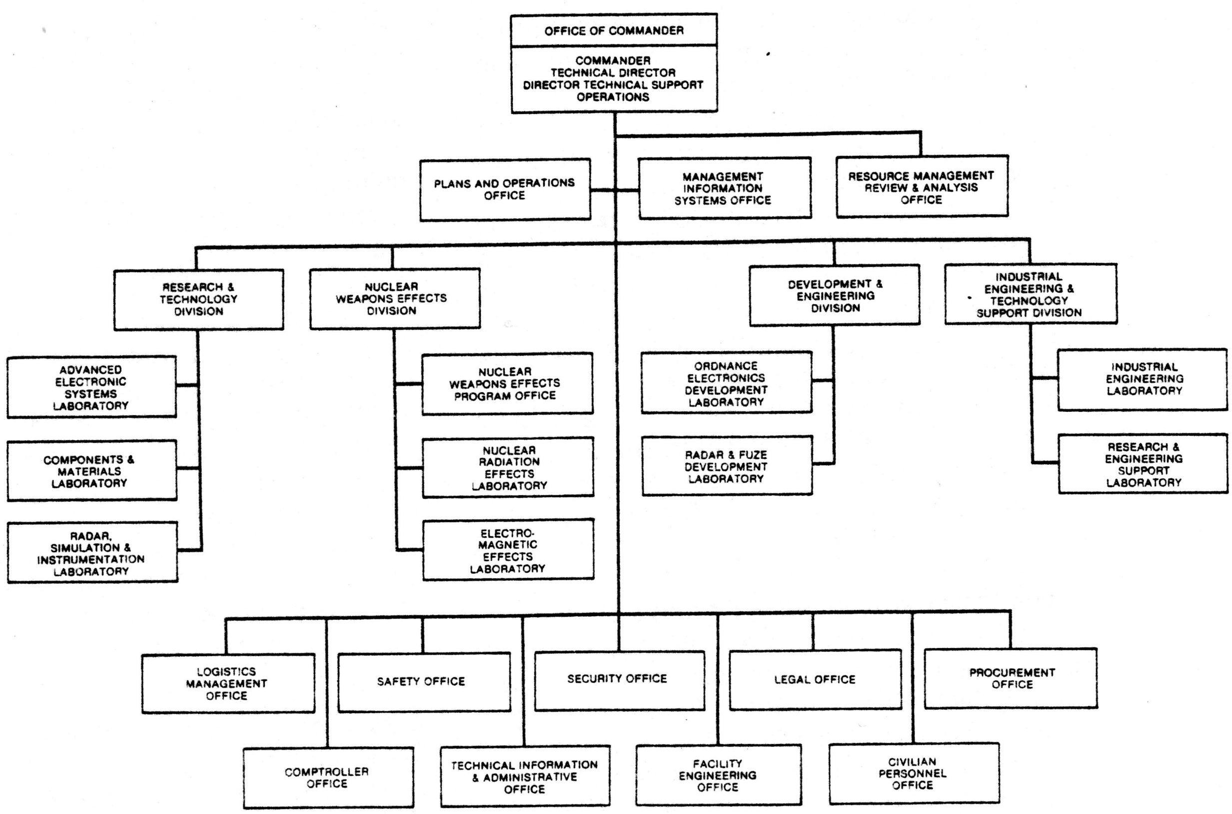


Figure 1. Organizational chart for HDL, FY 81.

restructuring of the Equipment Management Branch, to create a Property Book Accountability Section, and the consolidation of the former Supply Management and Issue Branch and the Material Acquisition and Disposal Branch into a single Supply Support Branch, consisting of a Supply Management Section and a Storage and Issue Section.

The reorganization of the Procurement Office entailed the realignment of manpower to support expanded responsibilities in cost/price analysis, procurement analysis, policy and guidance, industrial property management, and automated systems maintenance.

The Facilities Engineering Office was reorganized as a result of increased requirements in environmental and energy conservation and the accession of the Blossom Point Test Facility by DA. The reorganization involved the realignment of manpower to establish an Environmental/Energy Conservation Branch and a Blossom Point/Woodbridge Maintenance Shop.

Improvements to Contracting Office. With the acquisition of 12 Army Near-Term Readiness slots in FY 81, the HDL Contracting Office, for the first time in years, has an authorized level of staffing considered adequate to its mission. The increased strength made possible the formation of a Policy and Compliance Branch, long needed for effective management of the procurement function. With the current administration's emphasis on DoD activities, and concomitant decrease of emphasis on civilian agencies, the attrition rate in the office has dropped from a perennial 20 percent to nearly zero. During FY 81 the office fully achieved its mission of support for HDL, SWL, and designated outside agencies. The office negotiated and awarded 462 formal contracts and 8,000 small purchases, for a total obligation of nearly a quarter of a billion dollars. The prognosis for the office is excellent.

Commercial Activity (CA) Reviews. During FY 81, HDL completed CA reviews on the custodial, roads and grounds, and guard functions, which were initiated in FY 80. The completed reviews resulted in all functions remaining in-house and an allocation of 34 additional spaces in support of the custodial and guard functions. A request for three additional spaces in support of the roads and grounds functior awaiting DA approval.

In accordance with the FY 82 CA schedu HDL initiated reviews in FY 81 on the followi functions: facilities engineering (excludi custodial, roads and grounds, and direct R& support personnel); storage, issue, shipping, ar receiving; transportation, travel, and motor poc mailroom; and reproduction. HDL received e: emptions from DA for the mailroom an reproduction functions, resulting in a total of 5 Table of Distribution and Allowance (TDA spaces to be reviewed. The conduct of th management study and preparation of a statement of work for facilities engineering were awarded on contract. The management study and statement of work have been received from the contractor and are being reviewed and revised by HDL personnel. Management studies and statements of work for the remaining three functions were initiated and completed by HDL personnel. Cost comparisons of all functions are scheduled for completion by Jul. 82.

New Property Accountability Systems. The first-stage implementation of a Bar Code Inventory System (BARCIS) was completed with the application of bar-code labels to the 37,000 equipment items accounted for in the 1981 installation property inventory. This system, when operational, could reduce the man hours required to inventory property by more than 70 percent compared with the previous inventory method.

The property card system of property book accounting for hand-receipt holders was replaced with a single-signature hand-receipt listing. This new listing eliminates the need for hand-receipt holders to sign and maintain hundreds of individual property cards, simplifies the process of changing individual hand-receipt records, establishes a capability for frequent or as-needed update of individual hand receipts, and thus improves the probability that property book records are accurate.

Classified Document Control. In FY 81, classified Document Control Center personnel inventoried and reconciled all secret documents (approximately 30,000) with all 75 administrative accounts. This resulted in the

destruction or downgrading of 12,000 documents, of which 5,000 were library holdings. The Management Information Systems Office is currently preparing a program to automate the document accountability system, which should facilitate input, maintenance, and control of the document accountability system. Preliminary implementation of the automated systems will occur during the early part of 1982.

Union Activities. The American Federation of Government Employees (AFGE) and HDL management have completed negotiating an agreement for a union contract with guards and custodial functions at HDL. Formal signing of this agreement is expected in Dec. 81. Local No. 2 of AFGE, the officially recognized local of all nonsupervisory scientists and engineers at HDL, is currently negotiating with HDL management; these negotiations will lead to another union contract.

Resources Management Review and Analysis. During FY 81, the Resources Management Review and Analysis Office was primarily concerned with effecting the Commercial Activities (CA) program; in this regard, it conducted four cost studies and four management studies and prepared four statements of work; the result was a manpower authorization increase of approximately 34 spaces. The office also conducted 16 cost studies primarily in support of R&D projects, resulting in a projected cost avoidance of approximately $10 million. In addition, the office effected three reorganizations, initiated and/or reviewed 22 inter/intraservice support agreements, prepared four command briefings, and maintained the laboratories manpower program.

Merit Pay Program. HDL successfully completed the requirements of the Merit Pay Program and distributed the dollars in accordance with the requirements of the Office of Personnel Management. Each merit pay point for the unit including HDL amounted to $3.27.

Major Program Structure. The missions and funding assigned to HDL are derived from HDL's immediate major subordinate command, the Electronics Research and Development Command, from the Armament Research and Development Command (to a major extent), the Missile Command, and to lesser extents from DARCOM commodity commands and project managers, from the Defense Nuclear Agency (DNA), the Defense Communications Agency, the Department of the Air Force, and the Department of the Navy, and occasionally from some non-Defense federal agencies. The funds obtained from these various sources are distributed among HDL's principal technical programs approximately as shown in Figure 2.

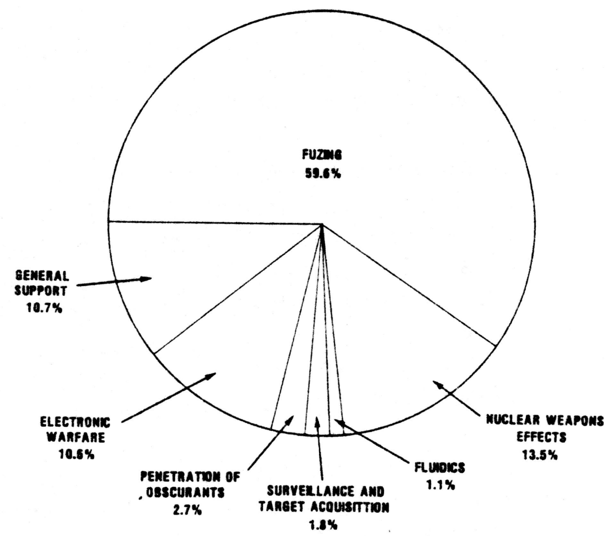


Figure 2. HDL program structure (percentages in parentheses).

Fuzing. HDL is concerned with the research, development, and initial production of electronic fuzes for both conventional and nuclear projectiles and missiles. HDL has a comprehensive program in fuzing technology, including investigations of target-sensing systems, electronic technology, materials, power supplies, safety and arming mechanisms, and various testing, instrumentation, simulation, and data-acquisition techniques.

Nuclear Weapons Effects. The nuclear weapons effects area includes system analysis and hardening of electronic material to survive thermal effects, transient-radiation effects, blast and shock effects, and the effects of both internal and external electromagnetic fields. HDL has also developed and demonstrated the Army's Hardened Tactical Shelter.

Fluidics. HDL's fluidics program concentrates on development and application of fluidic technology for use in ordnance, control systems, and instrumentation. Notable military-industrial applications include the fluidic temperature sensor and the emerging geophysical drilling transducer.

Surveillance and Target Acquisition. The surveillance and target acquisition area includes the personnel- and vehicle-detection radar technology base, as well as applications for physical site security and the simulation of foreign air-defense systems.

Penetration of Obscurants. Penetration of obscurants includes basic and exploratory development of NMMW technology.

Electronic Warfare. HDL's electronic warfare program includes management of, and technical contributions to, the Army's Anti-Radiation Missile Countermeasures program, as well as advanced development and technical support of a family of unattended, expendable communications jammers and development of the sensor for the anti-radiation projectile.

General Support. A variety of projects are classed as general support, including instrumentation, training aids, computer-aided design, and environmental simulation and testing. These include short-term projects, many funded by sponsors who are not a part of DARCOM, in which the unique HDL technological experience is freely transferred to other essential government requirements.

Personnel and Manpower. The number of full-time permanent civilian employees at the end of FY 81 was 1,030, an increase from the end of FY 80 (1,001). Other employees at the HDL facility at Adelphi, Md., who are not included in the above count, include 49 temporary HDL employees and also 205 HQ ERADCOM employees, 51 DARCOM Personnel Support Agency employees, nine U.S. Army Communications Command employees, and 11 BETA employees. Figure 3 shows the total civilian strength at HDL for FY 81, including full-time permanent employees, part-time or temporary employees, and HDL employees at Vint Hill.

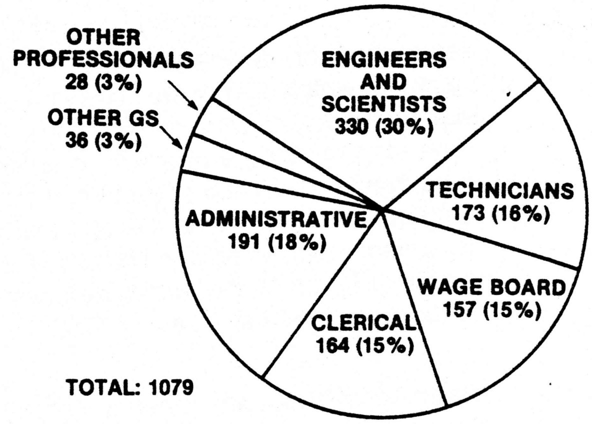


Figure 3. Breakdown of personnel.

The average grade of HDL employees at the end of the last three fiscal years is shown in Table 1. Full-time permanent/temporary strength decreased by 66 employees during FY 81, bringing the total to 1,079. The average grade decreased during this period from 9.9144 at the end of FY 80 to 9.8487. The decrease of 0.1217 is not considered significant.

Table 1. Average Grade Calculation

Category	30 Sept. 79	30 Sept. 80	30 Sept. 81
Full-time permanent	10.1411	10.2045	9.9481
Full-time permanent and temporary	9.9704	9.9144	9.8487

Engineer and Scientist Recruitment. Due to the intense competition for such personnel, attracting engineers and scientists (E&S) is one of the most important challenges facing HDL. Recruitment of these professionals continues to play a major role in the staffing function. During the past year, efforts to enhance E&S hiring included several innovations.

Responsibility for the recruitment of E&S has been centralized with one staffing specialist within the Civilian Personnel Office. This has provided greater emphasis to, and control over, the program. Use is made of the direct-hire authority for engineers GS-5 through GS-11 granted HDL by the Office of Personnel Management (OPM) on 22 Apr. 81. Eight engineers were hired under this authority. OPM has been requested to extend the direct-hire authority to include GS-12 engineers.

HDL has implemented the DA exception to CPR-950-1 which allows for the filling of E&S vacancies for positions GS-13 and above, through local merit procedures. This has simplified and expedited the filling of high-grade vacancies. Two accelerated training programs to provide for the promotion of entry-level engineers after six months are currently in draft form, and are being studied by the engineering staff.

In FY 81, the number of recruitment visits by HDL technical personnel increased considerably, resulting in 77 interviews with candidates at 12 colleges and universities. In FY 81, 20 E&S entered on duty in grades GS-5 to GS-12, compared with nine during FY 80. The intensity of competition for E&S is reflected by the fact that 66 candidates were originally selected during FY 81, many of whom declined to be appointed after their selection. In addition to the E&S GS-5 to GS-12 who entered on duty at HDL, there were four hires at HQ ERADCOM.

As a feed-in to the recruitment base, emphasis is placed upon the Cooperative Education Program. For FY 81 the number of students in the program was expanded to 41 compared with 33 in FY 80. Among E&S employed during FY 81, two were conversions from co-op employment. The number of student trainees, also a primary source of technical staff, increased in FY 81 to 21, an increase from 16 in FY 80. Emphasis continued to be placed on the related Federal Junior Fellow and Volunteer Programs. The number of volunteers increased to nine high school students (all interested in E&S careers) in FY 81, compared with five in FY 80. The Federal Junior Fellow Program, with a mix of students interested in engineering-related and other careers, increased to 24 from 13 in FY 80.

Training. The HDL Training Program is designed to address specific functional needs as well as other behavioral skills. These responsibilities expanded considerably with the advent of the Civil Service Reform Act. For example, great efforts were made to provide supervisors and managers with performance appraisal and labor relations training. To accomplish this, emphasis was placed on in-house training; 193 employees completed the labor relations training within a three-month period.

Emphasis continued to be on training within the facility when this was both feasible and practicable. Table 2 summarizes FY 81 training activities that were scheduled to meet our most critical needs as well as to continue other developmental opportunities.

Table 2. FY 81 HDL Employee Training

Source	Participants
Private industry	67
DoD schools	111
Other government	110
In-house courses	524
College & university*	106
Total	918
Types of on-site training	**No. of courses**
ADP	15
Scientific & engineering	7
Administrative	6
Management	11
Procurement	2
Total	41

*Includes 2 part-time fellowships and 1 full-time fellowship.

Individual contributions to science and technology continued as in previous years, as revealed by reports, presentations, patents, performance awards, and so on (see Table 3).

Equal Employment Opportunity (EEO) Program. Table 4 shows the breakdown of the workforce by grade, revealing the number of women and minorities in the various categories.

Progress is being made in the EEO area. The continuation of current trends in management support and resource allocation should allow even greater progress in the near future. For example, during the fourth quarter of FY 81,

Table 3. Fiscal Year Contributions and Recognition of HDL Personnel

Forms of Recognition	Number
External journal publications	67
Technical reports	82
Professional presentations	84
Attendance at professional meetings	174
Civilian graduate students	10
Military graduate students	
Full-time graduate or fellowship students (civilian)	1
Full-time graduate or fellowship students (military)	
Invention disclosures	41
Patent applications	24
Patents issued	28
Civilian personnel OPR	49
Civilian personnel SSP	52
Civilian personnel QSI	27
Civilian personnel special act	5
1981 recipients of Army R&D awards	5
Outstanding papers at 1981 science conference	
Total on-board strength as of 30 Sept. 81	1,079
Technical on-board strength (military and civilian) as of 30 Sept. 81	501

the staff of the EEO Office was increased by one space.

HDL managers and supervisors continued to demonstrate their support of the EEO program by encouraging HDL personnel to attend the cultural awareness activities held during Black History Month, Hispanic Heritage Recognition Week, Federal Women's Week, and Asian/Pacific Heritage Week.

FY 81 saw the establishment of the ERADCOM/HDL Equal Employment Opportunity Advisory Council—essentially a reconstitution of what was previously an HDL advisory body. Although the size of the EEO Advisory Council is not precisely controlled, it is now composed of 18 members, male and female, of all ages and ethnicities, and from various occupational areas and levels of the workforce. Members of the EEO Office staff sit as nonvoting members on the council, which has three elected officers: chair, vice chair, and secretary. The EEO Advisory Council will provide advice to the CG, ERADCOM, the Commander of HDL, and Commanders of any tenant organizations at Adelphi, Md. Some of the areas in which the council has expressed particular interest are upward mobility, merit promotion, and training opportunities.

Program emphasis on the recruitment of women and minorities into the E&S career field is a continuing requirement. Participation in the Armed Forces Orientation to Engineering Careers (AFOTEC) and the Pre-Freshman and Cooperative Education (PREFACE) programs is viewed as a means of attracting greater numbers of minority and female high school students into engineering schools, and of attracting engineering students to federal careers in E&S.

Activity in the Upward Mobility Program (UMP) during FY 81 was progressive, with the identification of nine additional UMP positions. As of 30 Sept. 81, 16 positions (or 1.5 percent of incumbered personnel authorizations) were identified as UMP opportunities. This represents 150 percent of the DA minimum goal, and 75 percent of the ERADCOM established goal of 2 percent of incumbered spaces. Continued progress is planned for FY 82.

In the area of special emphasis programs, the Hispanic Employment Program Manager was instrumental in having three DARCOM Interns assigned to HDL from Red River Army Depot in Texarkana, Tex. It is expected that this pilot project will demonstrate the feasibility of assigning such interns to DARCOM laboratories before they enter the structured aspects of formal training.

In spite of a decrease in the total workforce of approximately 6 percent during 1981, the representation of minorities in the workforce increased from 20.5 to 22.8 percent, and that of women from 26.7 to 29.4 percent. This change was accompanied by an increased presence of women in all portions of the

Table 4. Grade Distribution of Civilian Workforce, as of 30 Sept. 81

A. General schedule employees

Category	Total	GS 1-5		GS 6-9		GS 10-12		GS 13-15		GS 16 & above	
		Number	%	Number	%	Number	%	Number	%	Number	%
Authorized	1,038	141	13.6	119	11.5	526	50.7	248	23.9	4	0.4
On board	918	186	20.3	16.8	18.3	327	35.6	236	25.7	1	1.1
Total minorities:	166	39	23.5	53	31.9	59	35.5	15	9.0		
Black	135	36	26.7	47	34.8	43	31.8	9	6.7		
Hispanic	9	1	11.1	3	33.3	4	44.4	1	11.1		
Asian Pacific	19	1	5.3	2	10.5	11	57.9	5	26.3		
Amer. Ind./AN	3	1	33.3	1	33.3	1	33.3				
Total other	752	147	19.5	115	15.3	268	35.6	221	29.4	1	1.3
Total women	298	149	50.0	97	32.5	45	15.1	7	2.3		

B. Wage board employees

Category	Total	WG 1-5		WG 6-10		WG 11-15		Other WD/WL[1]		All WS[2]	
		Number	%	Number	%	Number	%	Number	%	Number	%
Authorized	161	44	27.3	43	26.7	47	29.2	15	9.3	12	7.4
On board	161	49	30.4	47	29.2	39	24.2	14	8.7	12	7.4
Total minorities:	80	39	48.7	26	32.5	7	8.7	4	5.0	4	5.0
Black	78	39	50.0	25	32.0	6	7.7	4	5.1	4	5.1
Hispanic	2			1	50.0	1	50.0				
Asian American											
Amer. Ind./AN											
Total other	81	10	12.3	21	25.9	32	39.5	10	12.3	8	9.9
Total women	19	16	84.2	3	15.8						

[1] *WD: Planners and estimators. WL: wage leaders.*

[2] *Wage supervisors.*

General Schedule (GS) grade structure above level 5; also, greater numbers of minorities have moved into "technician" or paraprofessional jobs, as well as into the entry and lower mid-levels of professional job series. This, of course, is a major ingredient in upward mobility on a broad basis.

The posture for Wage Board employees has not changed significantly. The employment of women in wage board areas and their movement into the higher grade levels continues to be a challenge.

Funding and Expenditures. HDL finances its operations through the Army Industrial Fund (AIF). HDL was originally chartered by the Assistant Secretary of Defense (Comptroller) on 21 Oct. 53. Subsequently, a single Army Industrial Fund Charter for DARCOM Industrial

and Commercial-Type Activities was issued on 3 Aug. 62. Those customer orders not meeting the criteria for financing by AIF are financed on an appropriation basis referred to as Non-Army Industrial Fund (NAIF). Currently, HDL's AIF cash allocation is $1,599,436; HDL replenishes this fund monthly by billing those customer orders which have incurred expenditures.

Funding. Total Obligation Authority (TOA) in FY 81, which includes carryover funds from prior years, amounted to $156.5 million. Of the total, $148.7 million was financed by Army appropriations, with the balance of $7.8 million provided by other DoD and federal agencies. The most important sources of income were HQ ERADCOM, the Armament Research and Development Command, and various DARCOM Project Managers. Table 5 gives details of funding from all sources including customers.

Table 5. FY Funding from All Sources Including Customers as of 30 Sept. 81

Source/type	FY 81	FY 82
DARCOM HQ RDTE funds		
6.1 Research	$ 3,573	$ 3,157
6.2 Exploratory development	7,531	7,971
6.3 Advanced development		
6.3a	4,340	4,968
6.3b	722	960
6.4 Engineering development		
6.5 Management and support	522	541
6.7 Operational systems		
Others		
Subtotal	16,688	17,597
Other RDTE funds		
DARCOM other	41,680	47,118
Non-DARCOM (other Army)	304	225
Non-Army	6,626	6,168
RDTE total	65,298	71,108
Procurement funds		
DARCOM		
HQ	1,270	1,230
Other	80,408	27,982
Non-DARCOM (other Army)		
Non-Army	198	5
PEMA total	81,876	29,217
OMA funds		
DARCOM		
HQ	2,661	2,145
Other	2,800	504
Non-DARCOM (other Army)	2,958	2,826
Non-Army	966	635
OMA total	9,385	6,110
Grand total	$156,559	$106,435

Execution. Total obligations of $117.5 million were recorded in FY 81. Expenditures for the year were $122.6 million, of which $60.0 million (49 percent) was AIF and $62.6 million was NAIF (see Tables 6 and 7).

The largest in-house (AIF) expenditure (see Tables 7 and 8) was for salaries and wages (54 percent). This represented 1,149 man-years of effort with an average salary of $28,200 per man-year. Of the total man-years, 449 (39 percent) were direct-labor man-years and 700 (61 percent) were indirect (indirect man-years are those in technical support services, laboratory supervision, and general and administrative support areas). Table 9 shows the distribution of man-years, profile of personnel, and workforce strength. Total expenditures in these areas represent HDL's operating and administrative overhead costs, which are distributed back to customer orders on the basis of a fixed charge per direct-labor hour. HDL's total overhead costs were $22.8 million.

Key Facilities. HDL occupies over 750,000 gross ft² at three locations: 84 percent at Adelphi, Md.; 11 percent at Woodbridge, Va.; and 5 percent at the Blossom Point Field Test Area, Md. The total value of the facilities excluding laboratory and office equipment is approximately $53 million (acquisition cost). Table 10 is a summary of HDL's real property.

Master planning has been completed for all but Blossom Point and provides considerable latitude for expansion to accommodate existing and new missions.

Currently under construction is a 5,800-ft² (gross) microelectronics laboratory. This facility is scheduled for occupancy in the spring of 1982 and will provide state-of-the-art laboratory facilities for semiconductor and related research and development.

Various projects related to environmental control, energy conservation, and land management are being enacted by the Environmental Coordinator's Office.

Table 6. Outside/Inside Obligations as of 30 Sept. 81

Effort	Total $K*	Industry and academia contract obligations		Other DARCOM labs' contract obligations		Other Government agencies' contract obligations		Estimated cost to administer**	
		$K	% of total	$K	% of total	$K	% of total	$K	% of total
RDTE funds									
6.1	4,377	68	2	16		221	5	2	
6.2	14,699	1,700	12	1,973	13	108	1	10	
6.3a	8,847	852	10	1,817	21	2,787	32	13	
6.3b	5,775	1,787	31	1,003	17	16		4	
6.4	12,809	4,635	36	685	5	342	3	8	
6.5	1,948	34	2	1				2	
6.7	594	176	30						
RDTE total	49,049	9,252	19	5,495	11	3,474	7	39	
Procurement funds									
DARCOM	578	453	78						
Other Army	63,477	50,899	80	51		648	1	1,478	2
Non-Army	157								
PEMA total	64,212	51,352	80	51		648	1	1,478	2
OMA funds									
DARCOM	2,661	74	3	107	4	2			
Other Army	646								
Non-Army	940								
OMA total	4,247	74	2	107	3	2			
Grand total	117,508	60,678	52	5,653	5	4,124	4	1,517	1

**Total obligations for each line: 6.1, 6.2, and so on.*

***In-house costs for purely administrative duties, both technical and managerial.*

Table 7. Total Expenditures AIF/NAIF (FY 81)

Type of expenditure	AIF		NAIF		Total
	$K	%	$K	%	
Salaries and wages	32,402	100			32,402
Supplies and materials	3,800	100	1	1	3,801
Contractual services	20,802	25	61,714	75	82,516
Capital equipment	1,599	66	828	34	2,427
Other costs	1,410	100	7	1	1,417
Total	60,013		62,550		122,563

Table 8. Percentage Breakout of In-House (AIF) Cost

Type of expenditure	%
Salaries and wages	54
Supplies and materials	6
Contractual services	35
Capital equipment	3
Other costs	2
Total	100

Average salary per man-year: $28,200
Average cost per man-year: $52,231

Table 9. Use of Personnel, as of 30 Sept. 81

A. Profile of technical personnel as of 30 Sept. 81.

Personnel	Authorized	On board	Scientists and engineers				Technicians	S&E		Technicians	
			Doctors	Masters	Bachelors	Other		Avg age	Avg grade	Avg age	Avg grade
Military	4	2		2				37.0			
Civilian	623	499	50	102	168	10	169	43.2	12.6	49.1	10.3
Total	627	501	50	104	168	10	169	40.1	12.6	49.1	10.3

B. Distribution of man-years of effort as of 30 Sept. 81.

Man-years	Funds					
	DARCOM			Non-DARCOM		
	RDTE	PROC*	OMA	RDTE	PROC*	OMA
Classified act total	525	282	57	99		19
Admin.	223	119	24	42		8
Prof. (S&E)	188	101	20	35		7
Prof. (other)	15	9	2	3		1
Technicians	99	53	11	19		3
Support						
Wageboard total	167					

*Reimbursable funding

C. Geographic distribution of personnel as of 30 Sept. 81.

Location	On board			Authorized		
	Military	Civilian	Total	Military	Civilian	Total
Adelphi	3	975	978	4	1,107	1,111
Woodbridge	1	84	85	1	71	72
Ft. Monmouth						
Ft. Belvoir						
WSMR						
VHFS		18	18	1	19	20
All others		2	2		2	2
Total	4	1,079	1,083	6	1,179	1,205

D. Supervisors on board vs. authorized strength as of 30 Sept. 81.

Category	Military		Civilian	
	On board	Authorized	On board	Authorized
Administrative		3	33	38
R&D technical	1	13	66	93
Tech./wage grade			19	32
Guard			5	7
Total	1	16	123	170

Table 10. Space and Property as of 30 Sept. 81

Acres		Space (thousands of square feet)				Acquisition cost (thousand $)		FY 81 S&E equipment	
Owned	Leased	Lab	Admin	Other	Total	Real property total	Equipment total	W/proj funds	W/non-proj funds
2,316		515	113	124	752	52,842	37,617	2,214	

chapter 2. mission summaries

fuzing

Fuzing of all types continues to be the largest single activity at HDL, as has been so since the establishment of the laboratories. However, fuzing now requires less than 50 percent of the funding and manpower, as other technical areas have grown.

During FY 81, the fuze technical base effort was severely reduced in real dollars from previous years, because of funding limitations in the Armament Research and Development Command (ARRADCOM) AH-18 technology base, of which the fuze technology base is a part. This reduction curtailed effort in several areas recommended by HDL as necessary to advance the state of the art in preparation for anticipated future fuzing developments.

Advanced development was completed on a fuze for the Navy's Shoulder-Launched Multipurpose Assault Weapon. Advanced development of the anti-radiation projectile fuze was initiated in FY 81.

Engineering development was completed on the Patriot missile fuze, which is entering production, and continues on two other high-reliability fuzes, one for the Multiple-Launch Rocket System and the other for the Army's new 155-mm nuclear projectile.

Two low-cost fuzes, the M734 multi-option mortar fuze and the M724 electronic time artillery fuze, developed over the past several years, continue in first production with extensive engineering support from the engineering development teams.

New fuzing development programs are expected during FY 82, which will require an increased technical staff.

Exploratory Development

Safety and Arming (S&A) Devices

Electronic S&A Device. Solid-state environment sensors, an electronic logic and firing circuit, and a special explosive barrier module (EBM) are combined to make a general-purpose electronic S&A device that can lower the cost and improve the safety and performance of future electronic fuzes. The EBM provides conventional barrier interruption using three propellant-driven interlocks in a simple, rugged, molded-plastic structure. In response to launch acceleration, in-flight aerodynamic forces, and arming delay signals, three identical electroexplosive initiators in a cover disc sequentially shear restraining pins on interlocked sections to unlock and align a fourth initiator for munition functioning. Since only 1 of 24 possible initiation sequences results in an output, this scheme minimizes the possibility of unsafe conditions from accidental initiation.

An initial exploratory development effort has been completed with publication of the contractor's final report detailing the design and test results of prototype S&A devices. Studies were done on environment sensors, a four-piece electronic driver circuit was designed and breadboarded, and many EBM's having wire bridges welded on a printed-circuit board were built and test fired. Results of the work to date show that the electronic

S&A concept is feasible, but further work must be done. An assembly technique to prevent cross-talk between the EBM's four charges, and detailed design of solid-state setback and air-flight sensors are problems that will be addressed in the coming year.

10-ms Stab Delay Detonator. Pyrotechnic delays are used in munitions to delay warhead functioning for maximum effect on target. Delay detonators that are stab initiated are more sensitive than percussion-initiated types; delay detonators are relatively new to the art because of the difficulty of achieving uniform delay times and stable performance in a unit punctured during initiation. Delay times as short as 10 ms have been especially difficult to achieve, because stable columns of most pyrotechnic mixes burn slowly in relation to this time.

A new stab delay detonator has been developed under contract for a sponsor at Missile Command (MICOM). It has an input sensitivity of 22 gm-cm, a nominal delay time of 10 ms, and is only 4.1 mm in diameter and 7.6 mm long. Over 700 units were built, and most were tested to qualify the design. This unit is now available for use in new fuzes, where it should be valuable in delaying function of the warhead until after penetration of fortification walls in urban battle operations.

Zig-Zig Acceleration Switch. A unique switch (fig. 1) has been developed for safety and arming applications in electronic ordnance. This switch uses an acceleration-driven weight, constrained by a zig-zag groove to move in an intermittent fashion, to actuate a miniature rivet-type contact assembly. The special design prevents closure under any shock pulses where the change in velocity is less than 16 m/s. Acceleration pulses of 300 to 30,000 g having a change in velocity greater than 65 m/s will close the switch. Once closed, the contacts will remain closed, without chatter, under the most severe shock and vibration environments. The contacts are rated at 30 V and 1 A continuous, with a contact resistance of 50 mΩ. The switch costs less the $1.00 and is only 8 mm in diameter and 25 mm long.

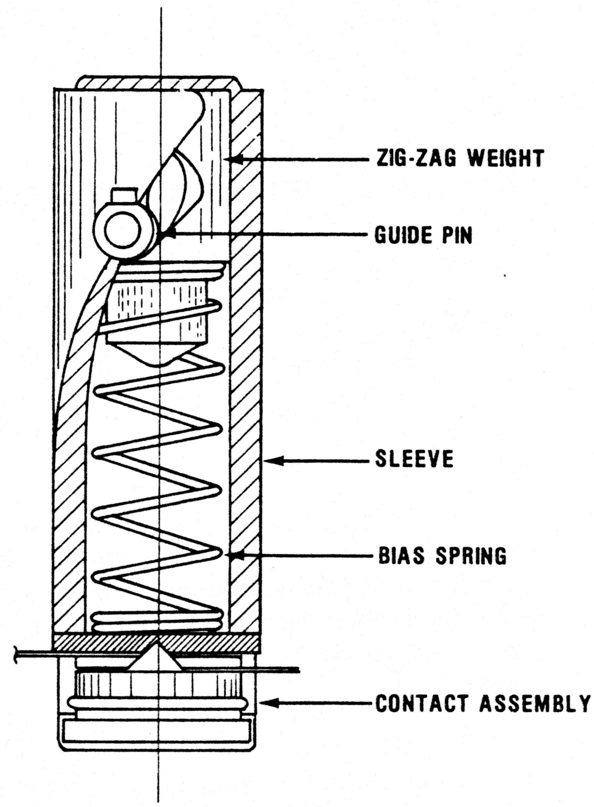


Figure 1. Zig-zag acceleration switch.

Fuzing for Advanced Air-Defense Missiles

Air-Target Optical Fuzing. The major emphasis in air-target optical fuzing research was on defining a baseline all-weather air-target missile optical fuze. This type of fuze requires 360° coverage in the azimuthal direction around the missile body; the resulting large sensing volume makes such fuzes particularly vulnerable to prefunctioning from aerosol backscatter. To overcome this problem, HDL is researching techniques using very short optical pulses to reduce the backscattered radiation relative to that of the target, and to allow discrimination based on the pulse streching normal in the aerosol return.

In FY 81 HDL obtained data on target-return pulse amplitudes and shapes for a fan-beam system encountering an aircraft, which was suspended by cables for the test. The overall purpose of the experiment was to determine firing points during the encounter. Encounters at various distances and angles were run, totaling 46. To

determine under what conditions and to what extent the target signal is stretched, video pulse-shape data of the return for a 5-ns transmitted pulse were recorded. HDL's pencil-beam aerosol backscatter sensor was modified to scan 180° to collect the data. Computer-processing methods were then developed to synthesize fan-beam sensor returns from the scanned pencil-beam data for any desired fan angle and also any desired range-response function, removing the effect of the range-response function of the experimental system.

Smoke backscatter data obtained in the previous fiscal year were reduced and analyzed in FY 81, with some of the results presented at the Smoke/Obscurants Symposium V. Results were obtained for both conventional (white phosphorus, hexachloroethane, fog oil) and experimental smokes (infrared screeners). Some of the latter proved to be highly depolarizing, of importance to systems using polarization discrimination. The backscatter parameter maps obtained after the data reduction give maximum values and gradients, information critical to assessing the effects of aerosols on optical fuzing systems. Figure 2 shows an extinction coefficient map for the experimental aerosol IR#2.

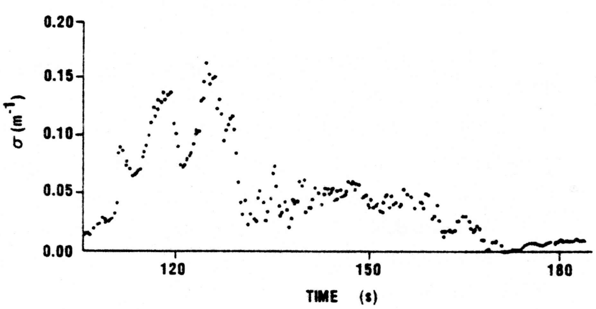


Figure 2. Extinction coefficient map for aerosol IR#2.

Computer programs were developed to produce cloud signatures from the cloud backscatter data bank that HDL has obtained over previous years, using its airborne aerosol backscatter probe and in-house developed digitizing system. The cloud signatures are independent of the response function of the system used to obtain the data, and can be used to calculate the pulse response of a specified system to the cloud segment that produced them, including the effects of all the nonuniformities and gradients. Software was developed to calculate the pulse response from the signature for fan- and pencil-beam systems. The fan-beam code simulates the baseline design for a quadrant-sensing air-target missile optical fuze with a 10-m function range, pulse width discrimination, and the range-response function optimized for the best discrimination.

Electronic circuitry for pulse-width discrimination was designed, and a successful breadboard was built during FY 81. The circuit accepts input pulses and provides different outputs depending on whether they are shorter or longer than 10 ns, regardless of amplitude. Previous modeling work at HDL has indicated that, for a 5-ns transmitted pulse and a proper range-response function, cloud-return pulses were longer than 10 ns, while target-return pulses were shorter or were so high that they could be identified as targets on the basis of amplitude alone.

Anti-Ballistic Missile Study. Fuzing against a ballistic missile presents an especially difficult problem. In general, the ballistic missile has a much higher velocity than the warhead fragments, and its vulnerability to these fragments is low. Consequently, the fuze-guidance system of the interceptor must track the target and predict its future position with sufficient accuracy so that the warhead can be aimed and its detonation timed to hit the target.

Concepts for a combined fuze-guidance system for the interceptor have been examined. The feasibility of the Kalman filter for tracking the target under the constraints of the engagement conditions has been demonstrated through digital computer simulations. The sensitivity of the error in warhead aiming to errors in measurement of range and bearing angles to target has been determined.

Air-Encounter Simulation. A joint program with the UK for The Technical Cooperation Program (TTCP) Panel W3 was completed this year. The program objective was to compare methodologies for computer modeling of fuzes. Target-signature data collected for this program are being used in a second joint program, now underway, to extend the comparison of methodologies to aircraft-target modeling. These models characterize the radar backscatter from aircraft and, when coupled with

fuze models, allow complete modeling of the fuze-target encounter.

Also completed this year was a simulation, for the Air Force Wright Aeronautical Laboratories, of enemy fuze performance against the B-1 bomber. This simulation will be used in conjunction with models of other parts of air-defense systems to determine the ability of the B-1 to penetrate defense networks.

Microstrip Planar Antenna. HDL has developed a computer program for the dimensioning of linear series-fed microstrip antenna arrays with specified beam angles and sidelobe patterns. This program was employed to design 8 linear arrays, each having 8 elements, to be combined into a 64-element planar array. The program calculates the size of each patch element and the spacing of the elements. The microstrip antenna shown in figure 3 was fabricated on 1/16-in. substrate. A stripline network is attached to the back of the array for the corporate feed of the series-fed arrays. The resulting antenna has a thin planar shape and is inexpensive to manufacture. It produces a "pencil beam" approximately 18° wide at the 3-dB points that can be scanned in the direction of the series feed from 0° to 45° off broadside by varying the frequency of operation; the gain is 19 dBi.

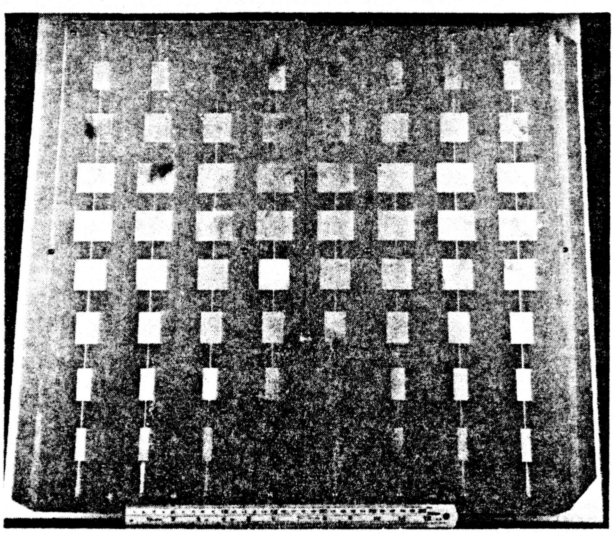


Figure 3. Microstrip antenna.

Monopulse Fuze. The objective of the monopulse effort is to develop a fuze system for medium-sized air-defense missiles that will locate targets accurately and have small-aperture antennas, resistance to prefiring and dudding, and integral FOJ (fuze on jam) capability. The feasibility of the use of the monopulse fuze system against an air target with and without the presence of electronic countermeasures (ECM) has been demonstrated by means of computer simulations of high-speed encounters based on data from low-speed field tests against a suspended A4D jet aircraft. Techniques have been devised and analyzed to provide passive-mode ranging, automatic optimum delay before firing, increased receiver dynamic range, and compensation for missile attitude angle.

A paper, *Monopulse Fuzing*, by Collins Arsem, was presented at the annual meeting of the Fuze Section, Ammunition Technology Division, of the American Defense Preparedness Association, March 17-18, 1981.

Ground Clutter at Very Low Altitude. HDL has completed initial investigations into the nature of terrain clutter for a radar fuze at very low altitudes. The radar signatures are such as would be seen by an air-defense missile engaging low-flying targets or helicopters hovering in treetops. Clutter statistics and power-density spectra change as a function of terrain type and altitude. These changes have been described using analytic clutter models as well as experimental data.

The experimental data have been reduced on IDEAS (Interactive Data Evaluation Analysis System) to generate amplitude and rate-of-rise histograms for the data, as well as spectral estimates. It was discovered that forests produce the worst-case clutter signatures, having the highest amplitudes and rates of rise and the widest bandwidths.

Roland Fuze Support. HDL continued to support the Roland program manager by performing simulation and hardware assessments of an improved Roland fuze. More than 2,000 scaled velocity target signatures were obtained and used to optimize critical fuze parameters, including a determination of necessary time delays between target detection and warhead detonation. The end-game section of the ROLSIM mathematical model has been validated with the target signatures. Captive flight tests of the fuze were conducted over pavement, grassland, and trees to verify the required

low-altitude performance of the fuze. A qualification test of the improved Roland fuze was performed. This required the construction of a new target simulator.

Digital Fuzing Techniques. Real-time synthesis of arbitrarily complex modulation waveforms and corresponding IF correlation waveforms through practical, inexpensive digital technology has been combined with a novel system configuration to yield a ranging device with enhanced ECM immunity. A system tailored to the conventional artillery height-of-burst requirement was fabricated, and it demonstrated exceptional performance in the laboratory. A hard-wired digital computer was refined that is dedicated to the generation of video waveforms associated with radar systems employing complex modulations. The signal simulator allows the testing of system performance in the laboratory to an unprecedented degree. Study of the performance of a new class of waveforms was begun. The waveforms are characterized by phase modulation through pseudorandom coding with complex frequency modulation. It is hoped that this modulation technique can significantly reduce the subsidiary peaks in the range/Doppler ambiguity plane. Chaff resistance at microwave frequencies is a matter of significant concern. A unique adaptive detection system is combined with the large information processing capacity associated with multipoint discrete Fourier transforms. The system, if properly implemented, can provide a powerful chaff/target discrimination capability. A real-time breadboard processor was fabricated and tested against experimentally obtained chaff signatures, with excellent results.

Fuzing for High-Explosive Multipurpose Tank Ammunition

Fuzing for Antiarmor Weapons. Presently available fuze designs for antiarmor weapons have less than optimum standoff capability, restrict the munition's angle of impact, and cause it to perform poorly in trajectories that penetrate brush. The inductive-influence fuze (IIF) overcomes these shortcomings by exploiting magnetic-field effects. The IIF is applicable to almost any shaped-charge warhead, although the development work to date has concentrated on tank-fired high-explosive antitank (HEAT) projectiles.

A developmental HEAT round for tanks is shown in figure 4 with the placement of the source and two sense coils illustrated. The source coil is driven by an ac source, and its magnetic field is sensed by coils on either side of it. When the field of the primary coil is disturbed by a conducting surface, the image field which is formed induces an output on the sense coils. This design provides countermeasure resistance to the far-field signal of various types of jamming coils.

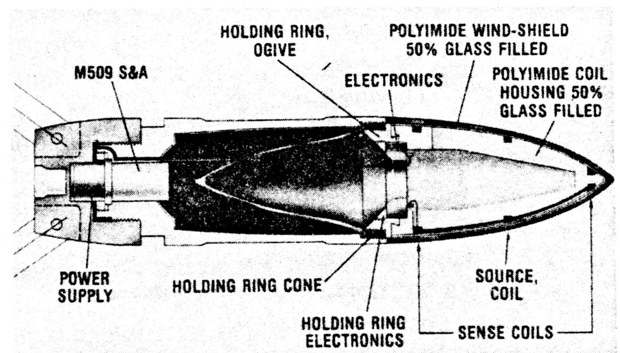


Figure 4. Conceptual layout of inductive-influence fuze in tank HEAT projectile.

A design has been competed for the fuze sensor to be incorporated into modified M106-mm, HEAT, M344A1 projectiles for use in feasibility demonstration firing tests. The firing of eight test rounds in the 106-mm recoilless rifle has demonstrated detonator initiation at approximately three cone diameters of standoff.

Standoff can be measured in the laboratory by firing a target (consisting of a hollow cylinder with a thin metal end) from an airgun at approximately 1000 ft/s (300 m/s) at a stationary sensor. The sensor is not damaged and can be tested many times.

Engineering of the circuit design has continued to lower parts count, improve resistance to microphonics, and increase standoff. The fuze-target interaction was modeled on a computer, so that coil geometries and amplifier sensitivity can be optimized. In FY 82, phase- and amplitude-detection circuits will be compared, and hardware will be fabricated for field testing.

Inductive Remote-Set System for Tank Application. The XM815 multipurpose HEAT tank round may require a remote-set system for setting a timer, for selecting the mode of function, and

possibly for muzzle velocity correction. The inductive remote-set (IRS) system can provide these functions.

The inductive data link consists of a transmitting coil wound on a gun-tube extension and a receiver coil in the ogive of the tank projectile. The ac inductive field which is set up inside the transmitter coil is received by the coil in the projectile. Pulse-width modulation of the carrier is used to send up to 20 bits of data to the fuze.

Breadboard circuitry of the word generator, modulator, carrier power amplifier, and transmitting coil of the setter unit, as well as the receiving coil, demodulator, decoder, and memory of the fuze electronics, was fabricated and tested in the laboratory. Most of this design was based on the fuze/function setter developed for the Navy Semi-Active Laser Guided Projectile. A demonstration firing of a complete IRS system on the M106 recoilless rifle is planned for FY 82.

Electrostatic Air-Target Fuze. Under most flight conditions, aircraft accumulate charge through combustion processes and triboelectric effects. An electrostatic fuze senses the charge field and is designed to cause detonation of the warhead at the most lethal position in relation to the aircraft.

Research efforts in FY 79 and 80 included gun firings of an electrostatic sensor past a 5.5-m long cylindrical target charged to −20 kV. Telemetry records contained target signatures that matched those predicted through analysis. Also present were outputs from other electric fields in the flight environment caused by near misses and impacts with vegetation and propellant gases venting from a fin-extension mechanism on the round. In FY 81, these records were digitized to perform computer evaluations of proposed signal-processor designs. The results showed that a simple processor could recognize the target signature in all records while rejecting other outputs during the flight.

This summer a field-test program was conducted to obtain target signatures for a helicopter in hover and forward flight. A facility was constructed at the Blossom Point test range to pull the elevated sensor and telemetry electronics past a target. Responses to a hovering UH1H helicopter were much lower in amplitude than those anticipated based on helicopter charge levels reported in the literature. The cause of this difference is under investigation.

Fuzing for Automatic Cannon

Division Air Defense (DIVAD) Gun. HDL has completed the evaluation of the performance of two DIVAD proximity-fuze candidates. This concluded a three-year evaluation process by HDL in support of the DIVAD source selection. During this period, the ECM performance evaluation of the proximity fuze was completed and reported. Also, the evaluation of the fuze performance when on a low-altitude engagement and exposed to terrain clutter was completed and reported. HDL is continuing to provide technical support to PM DIVAD during the preproduction phase of the DIVAD contract. This support includes evaluating fuze modifications and assessing the resulting changes in performance and reliability.

Fuzing for Advanced Antiarmor Systems

Down-Looking Fuze. At present, tanks in defilade are effectively protected from direct-fire weapons because they are obscured or because of the armor thickness that has to be penetrated. A munition that flies over the obstruction and can fire down at the target would be substantially more effective. Such a munition would require a sensor that can sense the tank target and provide fuzing information in an interval of a few milliseconds or less. The sensor must provide a target sensing range of 1 to 3 m.

A circuit has been designed which is similar in principle to an inductive metal detector. A source coil sets up an inductive ac field. The receiver coil is mounted in a plane perpendicular to the source coil (and parallel to the ground) so that ideally, when there is no metal nearby, the voltage on it is zero. When a conducting target is encountered, some of the inductive field is "imaged" back into the receiver coil. The voltage in the receiver coil is processed in order to produce a fire signal.

A breadboard circuit has been fabricated, and in order to demonstrate the concept, a projectile mock-up was tested for standoff against a T-62

tank. This test showed typical standoffs in the range of 0.5 to 1 m. A higher power transmitter has increased the standoff in the lab to 1.5 m.

This inductive metal-sensing concept may also be useful in a role of tank self-defense against helicopters. An Army Materiel Systems Analysis Agency (AMSAA) study has shown that a tank-fired HEAT projectile was much more effective against a HIND-D helicopter when fuzed with an inductive proximity fuze than when either time or contact fuzing was assumed. Future work on inductive fuzing will consist of improving standoff, increasing signal-to-noise ratios, increasing power, and optimizing coil configurations. Methods for countermeasure resistance will also be studied.

Other Exploratory Development

Modified M530A1 Fuzes. In response to a request from ARRADCOM for help in providing fuzes for development of an advanced, lightweight, high-velocity, 90-mm gun system, HDL designed, developed, built, tested, and delivered 100 modified M530A1 fuzes in a period of only 3 months. Forty of these fuzes incorporated the new 10-ms stab delay detonator described under *Safety and Arming Devices*. The other 60 units were adapted to function in the shortest possible time after impact at velocities up to 1,200 m/s. Special tests done to measure the functioning time of the explosive train yielded highly consistent results. These fuzes are forward-firing, base-mounted units, 32 mm in diameter and 50 mm long. They include a setback leaf mechanism for safety, an aluminum rotor for reliable arming under the high-drag flight environment, and an inertial firing pin for impact actuation.

Low-Cost Coding Switch for Hand-Set Electronic Time Fuzes. A low-cost means of manually selecting and displaying any one of up to 10,000 different time settings, without power, is a recent requirement for future electronic proximity and time fuzes. A new switch concept that meets these requirements within exceptionally low cost and space constraints has been modeled at HDL. The design (fig. 5) uses a printed-circuit-board membrane-type 4 by 4 matrix switch driven by 4 binary-coded cam shafts that detent in 10 positions; these display their positions through windows in a cradle used to hold the shafts and switch board. The cradle is contoured to match the fuze ogive. This six-part construction eliminates all discrete wiring and provides an inherently rugged and waterproof device as needed for fuze applications.

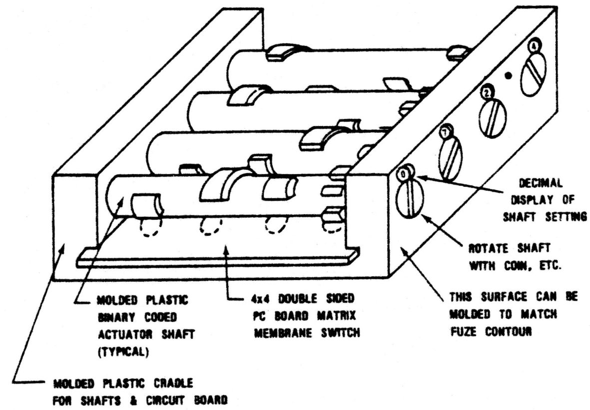


Figure 5. Low-cost coding switch.

Surface Proximity Fuze. The purpose of the surface proximity fuze (SPF) program is the exploratory development of a radar fuze for a high-velocity reentry vehicle (RV). For maximum effectiveness, the fuze must function at less than 1 m away from either the ground or any obstacle in the vehicle's flight path. The combination of adverse environment (particularly plasma attenuation), high fuze sensitivity, and high range resolution requires the use of advanced fuzing concepts and technologies. This program is sponsored by the Air Force Ballistic Missile Office (BMO).

After design and exploratory hardware effort during the earlier part of the program, contracts were let to build the fuze in a compact configuration suitable for mounting inside an RV for laboratory and slow-speed testing. Two units have been delivered and perform as expected, meeting the projected loop sensitivity, range resolution, and ECM performance. Although the sponsor has suspended the planned test and development program, the documentation has been prepared that will permit the reactivation of the project at a future time.

In a related project presently underway, this fuze with the sharp, close-in range response is used to measure the antenna leakage along different leakage paths on another RV.

Advanced Development

Active Optical Fuze for Anti-Radiation Projectile (ARP). HDL continued design work started in FY 80 on an active optical fuze for ARP. The fuze is designed to detect the ground and provide an acceptable height of burst (HOB) over any terrain, and not prefunction or be dudded in clouds, fog, or smokes. Because the projectile spins slowly and unpredictably, four equally spaced pencil-beam sensors are used, looking out at 60° from the projectile axis. Each sensor has a GaAs injection-laser transmitter and dual photodetector-amplifier signal-processing circuitry to provide near- and far-range response bins. The dual-channel receiving system allows the choice of two different HOB's for better effectiveness and minimizes the effects of aerosols on system performance.

IN FY 81, work progressed from the conceptual design done last year to the breadboard design stage. Transmitter and receiver optics fitting into the required small space were designed with the help of the National Bureau of Standard (NBS) and are now being produced in the NBS optical shop. Electronics for the transmitter and receiver have also been designed and broadboarded, and specific types of lasers and photodetectors to be used in the final design have been selected. Design work on the signal-processing electronics has also started. Calculations of the response of the sensor to natural clouds and CM smokes were carried out. Recently reduced data on gradients were used for some of the smoke calculations. A computer program was also developed to obtain the ARP fuze system response to clouds using the cloud signatures developed under the optical fuze research program. This program simulates the ARP transmitted pulse shape and range-response function; it calculates and graphs the peak values of the return signal that an ARP fuze would experience if it were flown through the cloud that the signature-measurement probe was flown through.

Fuze for Shoulder-Launched Multipurpose Assault Weapon (SMAW). The Naval Surface Weapons Center at Dahlgren (NSWC-DL) is developing SMAW for the Marine Corps Rapid Deployment Force. HDL has completed advanced development of the fuze for SMAW under NSWC-DL sponsorship. Weapon and fuzing concepts were described in prior ERADCOM posture reports and HDL laboratory reviews. During FY 81, developmental fuzes have been built and fired in many tests at Socorro, NM, and NSWC-DL, and at HDL's Blossom Point field-test facilities. A complete drawing package for the fuze has been prepared, and it is currently being used as the baseline for an engineering development contract calling for development and construction of 600 new fuzes for SMAW and development of simpler and more producible explosive-train components.

Engineering Development

XM445—MLRS Fuze. The Multiple-Launch Rocket System (MLRS) is a large-caliber multiple rocket launcher system intended to support conventional artillery by providing heavy firepower, especially in a battle surge condition. To achieve high survivability, a "shoot and scoot" concept is used. Two six-round expendable launch pods that serve as both shipping containers and launch platforms are mounted on a self-propelled launcher loader (SPLL), which is derived from the Army's infantry fighting vehicle. The weapon system employs an automated fire-control and aiming system with a remotely set electronic time fuze. The time-fuze concept chosen by HDL uses the electronics from the M587/M724 fuze with a fluidic power supply and gearless S&A similar to those developed for the XM444 rocket fuze.

The MLRS and the XM445 fuze are presently in a parallel maturation phase and limited production program. This approach is used for an Army "short development cycle" program. Contracts were let to a prime fuze contractor who was responsible for developing a producible design and documenting it in a production baseline technical data package (TDP). The cost of this design is monitored in a design to unit production cost tracking effort. Engineering development testing of fuzed MLRS rockets has continued at White Sands Missile Range (WSMR), resulting in 100-percent proper functions on 43 flights. The cumulative fuze test result for the validation and maturation phase tests at WSMR is now 93/93. First-article testing will begin in October 1981, with the first production lot scheduled for delivery in January 1982.

A modified fuze for the AT2 warhead being developed by the Federal Republic of Germany to carry antitank mines was designed, and fuzes and

drawings have been delivered. A successful flight program of 10 of these rockets was also completed during FY 81.

Plans for FY 82 include validation of the production TDP by engineering flight tests, environmental qualification tests, and a first-article acceptance test (FAAT) of limited production (LP) fuzes. After the FAAT, deliveries of LP fuzes to the MLRS prime contractor will begin.

The MLRS fuzes use two unique subassemblies, the fluidic generator power supply and a gearless S&A device. These improve the low-cost producibility of the fuze and together comply with the requirement in MIL-STD-1316 by sensing two independent postlaunch environments. These were described more fully in the FY 80 ERADCOM posture report and the HDL FY 80 Laboratory Review.

M818 Fuze for Patriot. The Patriot system is a mobile air-defense missile system being developed under the direction of the Project Manager's Office, DARCOM. Fuze development was delegated to HDL.

Engineering development has been completed successfully, with the fuze being type classified in August 1980. Extensive flight data analysis, captive-carry field tests, and computer simulations have been made to provide a comprehensive assessment of performance. High-speed automated fuze testers have been designed, fabricated, and tested. These fuze-level and missile-level testers, designed at HDL, employ modern microprocessor hardware and software with specialized rf hardware for flexible, accurate, and rapid automatic testing of complex equipment. These high-speed automated fuze testers were used in the final acceptance tests of the first production fuzes.

The production engineering planning (PEP) program, one of the largest such programs undertaken at HDL, has been virtually completed. Primary emphasis was on the design of special tooling and test equipment, the development of a government-approved manufacturing data package, and the development of production sources of highly specialized electronic components. The latter task has special significance because of the rapid changes occurring in the marketplace.

The initial production facility (IPF) program is nearing completion as the specialized in-line automated test equipment is proved out. An extremely comprehensive system for collecting, recording, and processing test data has been implemented. Trend data can be monitored to aid in anticipating problems and in taking timely corrective actions, as well as in facilitating a rapid determination of the cause of out-of-spec performance.

The first production fuzes are being delivered and are expected to be installed in the first production missiles in October 1981. These fuzes will undergo extensive and stringent environmental tests at the missile system prime contractor's plant. The fuze acceptance test equipment is furnished by HDL and is part of a complex computer-controlled system which is being designed and fabricated by the prime contractor. Over 2,000 data points are collected and must be within tight specification limits before a fuze is finally accepted as part of the certified missile system. Integration of the fuze test equipment into the contractor's computer-controlled system, followed by its certification, is the last major engineering task remaining in the program as the production rate of fuzes begins to accelerate.

A total of 24 fuzes has been delivered to date. The current production contract is for 255 fuzes to be delivered by November 1982. A total of five final-acceptance fuze testers has been delivered to the prime contractor's plant; three remain to be delivered. Fuzes and testers have been delivered in sufficient time to meet the prime contractor's needs. The prime contractor is late in delivering missiles and in bringing the missile final acceptance testers on line.

The Patriot fuze has performed well in missile flight tests. The most recent reliability, availability, and maintainability (RAM) test results (five flights) showed the fuze performing just as expected. Fuze performance was adversely affected when flight test parameters exceeded the system specification levels. There is an ongoing program to upgrade fuze performance to meet requirements beyond those currently specified.

XM749 Proximity Fuze. The new 155-mm nuclear projectile (XM785) requires a highly accurate and reliable proximity fuze. In the DOE/DoD Phase II Study, in 1976, HDL proposed a fuzing system similar to the recently completed M735 fuze for the 8-in. nuclear projectile, but in a much smaller total volume allocation.

The fuze consists of a target sensor system and a two-out-of-three channel programmer. A nose section, containing most of the three-channel programmer components and power supplies, will be stored separately for safer handling and storage; it will also be addressed by the fuze setter before assembly to the projectile to avoid applying voltage to the projectile.

A multichannel gun-rugged telemeter is being developed to monitor the performance of the fuze system in flight, by transmitting fuze output and diagnostic data to ground receivers.

The MX749 fuze programmer will be safety checked and set by the fuze setter, which will be based on the M38 fuze setter for the M735 proximity fuze.

Engineering development of the XM749 fuze for the XM785 projectile was begun in FY 79. The design is constrained by the DoD/DOE-negotiated mechanical and electrical interfaces between the XM785 projectile and fuze. Development is being conducted within HDL and under HDL's direction at Motorola Government Electronics Division.

The initial design of the fuze has been completed and several prototype units have been fabricated. The first prototypes of the new LSI (large-scale integrated) circuits were incorporated into the prototype fuzes. Overall system performance has been highly satisfactory, with volume having been significantly reduced through the use of these LSI circuits.

Gun-firing tests of fully functioning fuzes have been conducted successfully. Overall test results have been consistent with analytic predictions of mechanical structural and electrical system performance, although, as was expected and planned, minor design modifications are being made.

XM42 Fuze Setter. Development of the XM42 fuze setter for the XM749 fuze is continuing. A comprehensive system-level design has been completed. This design will result in a compact device that is highly reliable, but treats setting safety as paramount through special self-checking features. A study that will lead to selection of a primary power source for the setter is underway. Electrical, environmental, and field logistics issues are being jointly considered in this matter. At present, the XM42 is being designed to accept power from the HDL-developed G-76 hand-cranked generator as backup. Setter life-cycle maintenance is expected to be minimal. The extent to which it can be performed in the field, by exchange of circuit boards, will depend largely on the setter's self-certification capability. Current design efforts are aimed at balancing this function against the cost associated with increased self-test circuit complexity.

PS417 Power Supply. The initial design of the PS417 power supply for the XM749 fuze has been completed, and batteries have been built and successfully tested in gun firings. Electrolyte filling of the PS417 cells remains an area of interest because of the high dynamic and complex forces that occur during cell filling. Accordingly, a special-purpose ballistic test projectile has been designed to instrument battery performance in fine detail. Through onboard telemetry, cell filling has been monitored during the short-term in-bore interval as well as during the projectile flight interval. These tests are conducted using a realistic simulation of the time-load profile to exercise cell polarization and depletion.

XM749 Fuze Telemetry. Because the 155-mm projectile experiences severe in-bore acceleration, additional telemetry capability to monitor gun-launch transients has been designed into the XM749 telemeter system. Axial acceleration, balloting, battery filling, and eccentric spin data have been telemetered using the same special-purpose ballistic test projectile as for the PS417 power supply, above. For the collection of data from fully functional fuze tests, a pulse-coded modulation (PCM) scheme has been designed to facilitate computer processing; this should ultimately lessen significantly the time and effort required to reduce telemetered data, particularly during the concentrated phase II developmental tests (DT-II). It is also

expected that the acquisition cost of the PCM telemeter system will be less than that of a technically comparable FM system.

Particular attention is being given to the mechanical design of the telemeter system to insure recovery of projectiles and on-board electronics. Multiple refirings of the electronics are planned to reduce cost.

Procurement and Procurement Support

M818 Missile Fuze. The M818 fuze for the Patriot missile was developed at HDL under the sponsorship of the Patriot PM. It is a proximity fuze used with the M249 high-explosive guided-missile warhead section; it contains a high-reliability transmitter, hybrid microcircuits, and a single large-scale integrated logic element that performs most signal-processing functions. Notification of type classification was received in September 1980. A contract for the first- and second-year production buy of 255 fuzes was awarded to the Bendix Corp. in the second quarter of FY 80. The first production unit was delivered in July 1981, with deliveries continuing through November 1982. Thus far, only sensor assemblies have been assembled to missile hardware. The first production electronic assembly with associated cables will be assembled into the first production missile early in FY 82. The current plans are to have HDL make all future procurements, which extend through FY 90.

Initial Production Facility, M818 Proximity Fuze. In preparation for the first procurement contract for the M818 proximity fuze, the Bendix Corp. Communications Division, in Baltimore, MD, was selected to design and fabricate an initial production facility (IPF).

The IPF contract, signed in October 1979, will be completed during the second quarter of FY 82. The equipment constructed will be able to assemble and test five acceptable units per eight-hour shift, at a net rate of 80 units per month (20 days) on a 1-8-5 basis (one eight-hour shift, five days a week); a 90-percent availability of machinery is a goal.

The total value of the IPF contract will be $8 million. Special tools, special test equipment (STE), special acceptance inspection equipment, and final fuze acceptance test equipment are included in this IPF.

M735 Proximity Fuze. The M735 fuze was developed for the 8-in. nuclear projectile (XM753) which requires a highly accurate and reliable radar proximity fuze.

The fuze consists of (1) dual-channel radar ground target sensors, (2) a two-out-of-three coincidence logic multiple-channel programmer for in-flight safety and arming and sensor turn-on, and (3) dual liquid-reserve power supples, which provide arming and warhead electrical function power, fuze sensor power, and handling safety. The FY 79 ERADCOM Posture Report and HDL Laboratory Review contain more detailed infomation.

The first procurement contract was let to Motorola, Inc., late in FY 79, after five years of development by HDL with Motorola support. The first-article sample tests were completed in the second quarter of FY 81, launching a production program which will run continuously through FY 86.

M38 Fuze Setter. The M38 fuze setter, type classified in January 1980, is designed to set in-flight timing and option-selection data into the M735 fuze nose section just before firing. All required setters are being bought in a contract let with Motorola, Inc., during FY 80. Delivery of the first units was made in June of FY 81. Production will continue through FY 82.

G-76 Direct Current Generator. The G-76 hand-cranked power source was developed under the sponsorship of PM-Army Tactical Communications Systems (ATACS) for use in support of the new Special Forces Burst Communications System (SFBCS) which provides voice and data communications between base stations in friendly territory and air-dropped outstations operating in hostile areas. The G-76, which replaces the G-67 and G-77, is used to directly power the AN/PRC-70 and AN/PSC-1 radios, and to recharge the BB-542 battery. In addition, the G-76 has been adapted under the sponsorship of PM-Nuclear Weapons (PM-NUC) to power the T-1333 Permissive Action

Link (PAL) for use on the M753 8-in. nuclear projectile. The G-76 weighs 13.8 lb (~6.2 kg) and is collapsible. It is carried in a canvas combat carrying bag along with its power cables and is readily man portable. The generator uses an alternator having a samarium-cobalt magnet rotor. This use of high-energy magnets in conjunction with a harmonic drive assembly, which serves to increase the input rotational speed by a factor of 81:1, allows the alternator to generate 200 W when driven at an effective speed of 8000 rpm.

A letter contract (DAAK21-80-C-0096) was signed in the first quarter of FY 81 with the USM Corp., Wakefield, MA, for production of the harmonic drive assembly which is being supplied as government-furnished material (GFM). A letter contract (DAAK21-80-C-0084) for the initial production of 400 G-76 generators and accessories was signed in the fourth quarter of FY 80 with the Simmonds Precision Corp., Norwich, NY. An option for an additional 711 generators (sponsored by PM-ATACS and PM-NUC) was awarded in the third quarter of FY 81. First-article tests are nearing completion, with initial operational capability scheduled for the first quarter of FY 82.

M817 Target-Detecting Device. The M817 target-detecting device (TDD) replaces the Navy Mk15 TDD and is part of the improved Chaparral missile (MIM-72C). It was developed by HDL under the sponsorship of the Chaparral PM.

HDL has procured 5,740 TDD's to date from two sources. International Signal and Control Corporation completed delivery in 1979 on 3,784 TDD's under three different contracts. A competitive contract (DAAG39-78-C-0017) for 948 TDD's with LaBarge was completed in August 1980. An add-on to this contract of 998 TDD's was completed in the spring of FY 81. A competitive fixed-price contract was signed in the third quarter of FY 81 with the LaBarge Corporation for 800 more units. Current plans are to transition the procurement responsibility of the M817 to MICOM early in FY 82.

M734 Multi-Option Mortar Fuze. The M734 fuze is designed for use on the M720 60-mm high-explosive cartridge of the Lightweight Company Mortar System (LWCMS). The first procurement for stockpile is being accomplished in conjunction with the design, construction, and prove-out of IPF's for alternator, amplifier, and fuze assemblies.

Monthly deliveries to a slipped schedule are being met, with a total of approximately 350,000 amplifiers, 250,000 turbine alternators, and 125,000 fuzes shipped.

Amplifier assemblies are produced by Motorola Corp. and supplied as GFM to Eastman Kodak Co., the fuze contractor. Problems with IPF equipment deliveries and production yield have been mostly overcome, and currently the production rate of 25,000 per month is being attained. Increased rates, to 50,000 per month, are contemplated upon successful implementation of an improved amplifier design.

Fuze assemblies produced to date have been demonstrated to be safe and performance generally good but slightly below the material-need requirements for dud and early functions. Dud problems are attributed to unrealistic test conditions attempting to simulate arctic firing..An engineering change proposal (ECP) has been prepared to correct this inconsistency. Early function rates have been significantly reduced by a value engineering change proposal (VECP) amplifier electrical-shield can design implemented into production. Approximately 60,000 fuzes have been loaded and placed in stockpile.

M734 IPF. In conjunction with the first procurement contracts for the M734 multi-option fuze, each of the selected contractors is required to design and construct an IPF as follows:

Motorola, Inc.	Amplifier assembly IPF
Alinabal Corp.	Alternator assembly IPF
Eastman Kodak Co.	Fuze assembly IPF

The IPF construction has been concurrent with the first-year production of hardware. The entire second-year delivery quantity is to be produced on the IPF. Following prove-out, a TDP is to be provided which will allow the IPF to be reproduced as necessary to satisfy mobilization base requirements. The design rate for the fuze IPF is 100,000 units per month These rates are based upon plant operation on a 1-8-5 basis (40-hour work week).

Turbine alternator and amplifier IPF's have been accepted with rates below the original requirements. Manual stations or duplication of existing machines can be used to achieve the original required rates of 106,000 per month for these fuze subassemblies.

M724/M36 Electronic Time (ET) Fuze System. The M724 ET fuze and M36 setter were developed as a system to supplement a declining M577 mechanical time (MT) fuze production base. Type classification of the M724 occurred in January 1979, and three-year multiyear contracts were awarded in August 1979 for construction of a high-rate IPF and for production of the M724 system; the first-year contract value was $27 million. A congressional review of ET versus MT cost effectiveness, however, initiated an Army directive in March 1981 to lay away the M724/M36 system, in favor of revitalizing the MT production base and developing the XM762 ET fuze with the hand-set capability preferred by the user for logistics reasons.

Production quantities of the M724/M36 system were subsequently reduced by cancellation of the FY 81 procurement to numbers which would assure minimum prove-out of the IPF, completion of cost-reduction programs on the fuze and setter, and economical completion of the program. Fuzes produced in this phase of the program are not scheduled for deployment. They will be stored for possible future use.

Preparation for layaway of the fuze and two power-supply IPF systems are underway. The layaway will be designed to permit rapid, economical restart in the event of an M577 shortfall or mobilization. Obsolescence of the technical data packages will be monitored during layaway as part of a product-improvement program to assure production readiness until the XM762 ET fuze is fielded.

M732 Proximity Fuze. The M732 artillery proximity fuze (fig. 6) is HDL's product-improved short-intrusion design to supplant the long-intrusion M728 fuze. It is used on the 4.2-in. mortar, and on 105-mm, 155-mm, 175-mm, and 8-in. artillery ammunition. It is currently undergoing qualification tests for use on the M549 rocket-assisted projectile. Contract awards for production of M732 fuzes by the Armament Materiel Readiness Command (ARRCOM) to Raytheon and Lockheed Electronics Companies continue for a combined delivery quantity of approximately 600,000 fuzes per year.

Figure 6. M732 artillery proximity fuze.

In accordance with provisions of the transition plan to transfer responsibility for the M732 fuze to ARRCOM, HDL is providing engineering design and limited quality-assurance support to the M732 production. HDL retains responsibility for the fuze design and maintains the master drawings and specifications of the TDP configuration in support of ARRADCOM.

A product-improvement program is underway at HDL to incorporate the lower-cost M724 fuze S&A into the M732 fuze.

HDL has awarded a contract to the Raytheon Company to redesign the M732 turning capsule/sleeve interface to improve the resistance to in-bore fuze resetting. The M732 fuze was type classified with the provision that the resetting tendency in the high-spin environment be corrected and the correction implemented in production as soon as available.

HDL has awarded an engineering service contract to Lockheed Company for redesign studies of M732 production problems. The contract includes various tasks: the timer/detonator interface is being studied to upgrade the connection between the two components and thus improve the reliability of the explosive train; changes in the amplifier polyurethane foam potting process are being examined to improve foam distribution and provide more uniform density; and a redesign of the timer eyelet that would allow improved assembly and solder operations is being studied.

Product Assurance. Product assurance involves total quality control, which has been defined as an effective system for integrating the quality-development, quality-maintenance, and quality-improvement efforts of the various groups in an organization, so as to enable production and service at the most economical levels that allow for full customer satisfaction. At HDL, the disciplines of quality assurance, test equipment certification, engineering testing, and reliability make up the product assurance functions, which have the goal of providing to the government materiel which conforms to contractual requirements in a cost-effective manner. All requests for procurement actions in excess of $10K are reviewed for adequacy of quality-assurance provisions, whether for studies, research, supplies, or hardware. Testers and test equipment support are provided for (1) inhouse fuze development, (2) verification before certification, and (3) evaluation of in-line production test equipment used at government contract facilities. The product assurance activity supports periodic tests to monitor reliability of stockpile systems.

Quality Assurance. Product quality management, to be effective and efficient, is dependent upon a close working relationship between quality personnel and design, development, product, and procurement activities. This relationship begins during the R&D phase and continues through the production phase of a program. The product quality manager is normally involved in closely monitoring four main areas: (1) new-design control, (2) incoming material control, (3) product control, and (4) special process studies. Product quality management (PQM) was provided on 21 production contracts, totaling approximately $163 million. Additionally, this section provides direct interface between the Defense Contracts Administration services and the procuring activity for HDL/ERADCOM.

Test Equipment. In support of government procurement, technical personnel verified calibration and operating procedures for special acceptance test equipment, and assessed production test equipment for accuracy, stability, and performance criteria in the contractors' facilities for HDL's programs.

Expert engineering support was supplied to laboratories within HDL in the area of computer-controlled testing. Personnel responsible for equipment designed a complete computer test system with software used in debugging units of the M734 fuze program. A duplicate calculator-controlled test program was designed, fabricated, and installed at the contractor facility to support the PS416 power supply development and production.

Engineering Testing. Engineering support was provided to perform failure analysis, flight test monitoring, and special test equipment maintenance and operator's training. Firing tests were supported through test monitoring, data analysis, and anomaly studies for the M1140 and Honest John fuzes. Special stockpile laboratory tests on the T361 were performed. Components testing of the M734 fuze was accomplished to verify production test data and abnormalities.

Reliability. During FY 81 an extensive reliability analysis of the M734 fuze was performed. It incorporated ballistic lot acceptance test data from the first 10 production lots as well as first-article acceptance sample and engineering test data. The Patriot fuze program reliability prediction was updated using a refined mathematical model which closely reflects current design. The updated prediction was forwarded to PM-Patriot for inclusion in system documentation. The preparation of a storage reliability test plan was begun to determine effects of long-term storage on critical fuze components. Because of reliability staff shortages, the Reliability Analysis Center (RAC) in Rome, NY, was

contracted to perform a reliability analysis of the M732 fuze. The final report on that effort is due early in FY 82.

This staff continued to evaluate ECP's on production programs for their effect on reliability. Consulting services in statistical analysis, confidence limits determination, and review of contractors' reliability documentation were provided as needed to various programs.

Component Reliability. The component reliability group certifies components as reliable for fuze use. In order to do this, the component reliability group has provided the theoretical and practical tools to allow the prediction, testing, and demonstration of the probability and capability of components to perform their required functions without failure for desired periods in specified environments. One important test is an actual gun-firing, which is used to demonstrate a component's ability to survive ballistic forces. Both active and passive electronic components have been shock evaluated in this manner, including integrated circuits, which offer advantages of reduced size and weight, lower cost, and high reliability. The integrated circuit alone has been a cause for the generation of many new military specifications. This is primarily due to rapid acceptance of integrated circuits. Each year a document has been published describing components which are qualified for use after a successful demonstration in this controlled environment. The Component Reliability Group has also conducted HDL's GIDEP (Government Industry Data Exchange Program). This program gives access to an extensive reservoir of component reliability information, gathered from many sources affiliated with the defense effort, both within the government and in private industry.

Production Base Support (PBS)

Program Funding. In FY 81, five new production base support (PBS) orders were received, and three prior-year orders received supplementary funding, which added a total of $320,251 to HDL's Army Industrial Fund (AIF). (An additional $1,265,734 of non-AIF funding was provided for internal HDL facilities and contracted manufacturing methods and technology (MMT) effort.) The PBS AIF funding can be categorized as shown in table 1.

Table 1. FY 81 PBS AIF Funding

By sponsor	No.	$ value
DARCOM	1	61,266
ERADCOM	1	200,000
ARRCOM	1	161,000
AMMRC	2	190,400
By fiscal class	**No.**	**$ value**
4211	1	61,266
4250	1	161,000
5397	2	190,400
728011.3	1	200,000

Manufacturing Methods and Technology. The three primary objectives of the MMT program directed by the DARCOM Office of Manufacturing Technology are

- to improve the manufacturing process, techniques, and equipment used to manufacture Army weapons systems,
- to bridge the gap between the developmental process and full-scale production, and
- to support the modernization of the Army's production base.

HDL has several ongoing MMT programs. A summary of these programs follows.

Pilot Line for Fuze Fluidic Power Supplies. The objective of this MMT project is to develop economical and reliable manufacturing processes, to reduce production costs, and to develop techniques for the establishment of a mechanized pilot production line to produce fluidic generators for fuzing applications.

The fluidic device is currently being developed as both a power supply and an environmental safety sensor for the XM445 fuze for MLRS. The fluidic device is versatile and rugged, has few moving parts, and has long storage life. However, the proper operation of the device depends largely on a complex geometrical configuration in which allowable dimensional deviations and interplay be-

tween component parts are extremely sensitive and critical. The lack of specialized production equipment and assembly techniques has resulted in high manufacturing costs and a low production rate.

This MMT effort consists of three phases. Phase 1, which is completed, is related to the design and analysis of a pilot production facility that could fabricate, test, and assemble the fluidic generator. It also included a review and redesign of the components and specifications as necessary to improve mass producibility while reducing costs.

Phase 2 consists of designing, fabricating, proving out, and documenting a specialized automatic facility and equipment to completely test the fluidic generator in all conditions depicted by the specification control drawing.

Phase 3 is the design, fabrication, and prove-out of an automatic machine for assembling the coil and magnet assembly section of the fluidic generator.

Also included in these three phases is the requirement to prove out and document the investment casting mold equipment and processes for the production of the magnet keepers for the fluidic generator. HDL is currently under contract to KDI Precision Products for all the above programs.

Low-Cost Molded Packaging of Hybrid Electronics. At the end of FY 80, a contract was awarded to Springborn Laboratories for the identification and evaluation of combinations of encapsulants and molding processes suitable for high-speed, low-cost packaging of hybrid ordnance electronics. During this fiscal year, Springborn conducted a state-of-the-art survey of high-speed molding and materials and related integrated-circuit technology, designed and fabricated a multipurpose mold to be used with a variety of processes, ran pertinent laboratory tests on interesting materials, and attempted to mold M734 amplifier boards using a liquid-transfer moldable epoxy, a liquid-injection moldable silicone, and a reaction-injection moldable urethane. Initial results are promising in that all three techniques have been used successfully to encapsulate circuits. Further refinements in the processes and evaluations of the materials should lead to a recommended combination of a material and process that will protect the hybrid electronics from the ordnance environment.

High-Volume Printed-Circuit Producibility. Large numbers of ordnance programs use the HDL prototype printed-circuit (PC) facility to fabricate a wide variety of boards. Boards range in complexity from simple, single-sided component boards to complex multilayer and rf PC boards. However, prototype PC techniques are not readily adaptable to methods used in commercial PC production. Redesign and retesting escalate program costs, because design changes are required to transform prototypes for production PC processing.

The solution of this problem comes in the form of a high-volume PC producibility program. The program uses production techniques and equipment to fabricate prototypes for laboratory evaluation. Production rates of about 1,800 boards per day are possible. The advantage of this solution is that previously difficult-to-manufacture items will now have a production history, thus resulting in a smooth transition between the prototype and production cycles. This solution is most applicable to antennas, rf stripline circuits, filters, and microwave circuitry.

This program has completed its equipment purchases and is accumulating production-rate data to be presented in a final report.

Three-Axis Vibration Testing. The FY 79 MMT-sponsored project for the design of a computer-controlled three-axis vibration test and simulation system was completed during 1981. The test system was designed to impart to a test item in any spatial direction a sinusoidal vibratory vector up to 500 Hz and random vibrations in three-dimensional space in the frequency range of 20 to 2,000 Hz. Peak design amplitude is 40 g with a 100-lb (46-kg) payload. An engineering data package for this system was developed which outlines the system's configuration, subsystem design, vibration control schemes, and predicted dynamic behavior of the excitation subsystem. A prime element of the three-axis system is a unique excitation subsystem which converts three unidirectional vibration inputs, produced by three orthogonally aligned

shakers, into a simultaneous three-dimensional vibration vector. Since each shaker's amplitude and phase can be programmed independently of the others, a variety of vector trajectories can be achieved on the test platform. Real-time vibration control is provided by a closed-loop digital control subsystem which monitors and corrects the spatial vibratory components of the test platform, near or on the test item. A cutaway section of the three-axis system, showing its major elements (excluding the control subsystem), is presented in figure 7.

The objectives of the three-axis system are to enhance test realism, reduce testing cost, and provide a practical means of testing and/or sensing along directions of vulnerability of the fuze which do not coincide with any of three orthogonal principal axes. Since the logistical and tactical environments for fuzes (rockets and missiles in particular) are complex and multidirectional, the system will be capable of simulating these environments in a way not currently achievable with unidirectional testing. Cost is reduced by limiting tests to directions of vulnerability of the fuze, thus eliminating test conditions for which insignificant vibration damage develops.

Fluidic High-Temperature Measurement. The fluidic capillary pyrometer (FCP) has been incorporated into an all-pneumatic control system for use in the 155-mm rotary furnace at the Scranton Army Ammunition Plant, under the auspices of the DARCOM MMT program. Life testing, started in FY 80, shows no detectable calibration shifts even after 5,000 hours at over 2,000° F, and manufacturing methods analysis of sensor probes indicates that the probes may cost about $100 each in production quantities. This means that a truly low-cost, reliable system with good return on investment, as shown in table 2, can be incorporated in the Army inventory.

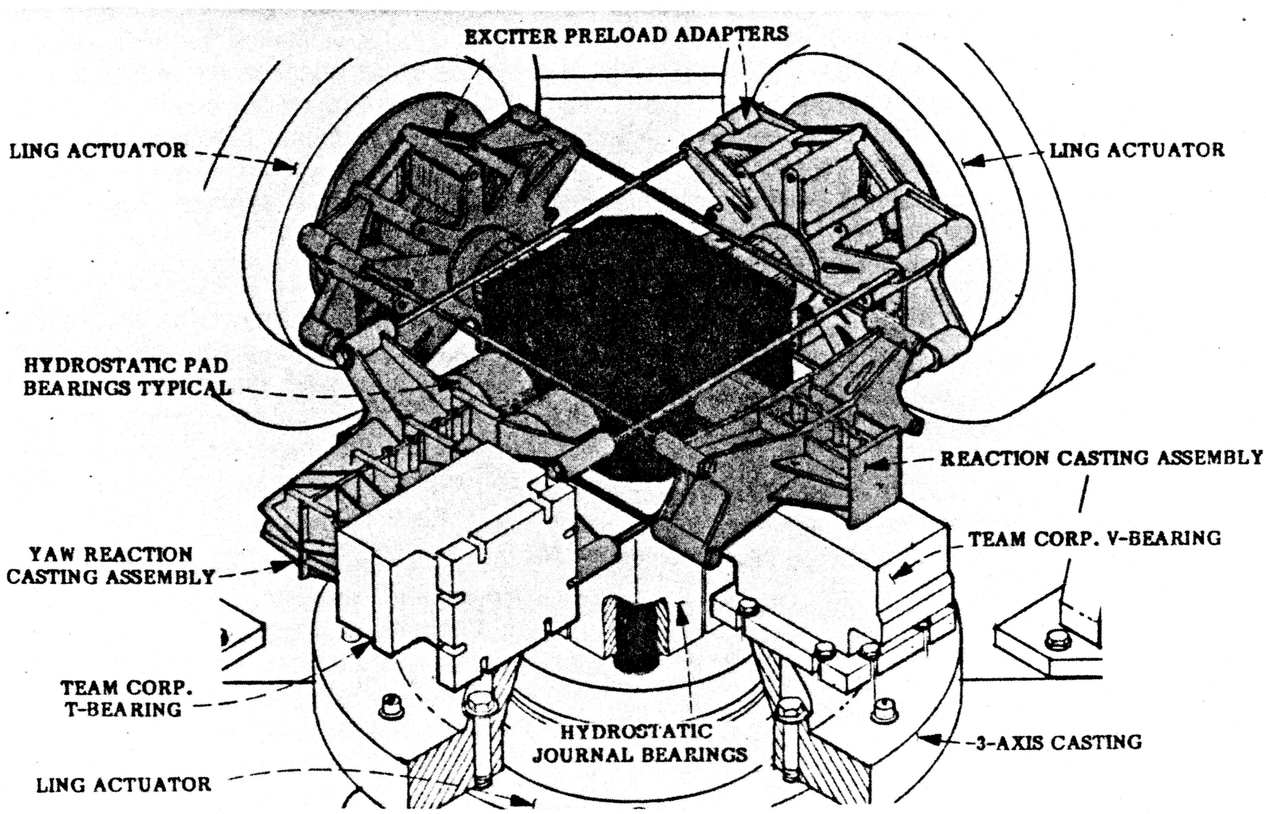


Figure 7. Three-dimensional vibration simulator, cutaway view.

Table 2. Fluidic Capillary Pyrometer Return on Investment (ROI)

Forging furnaces (155-mm rotary hearth, 10-year amortization)	Annual ($K) cost	saving
10 systems	1.0	—
10 probes	1.0	—
Retrofit	5.0	—
Serving	—	5.0
Replacement	—	2.0
Energy management	—	28.0
Gross annual cost	7.0	
Gross annual saving		35.0

ROI = saving/cost = 5.0

Manufacturing of Fluidic Amplifiers by Cold Forming. A project is underway to investigate the use of fineblanking to manufacture fluidic laminates. Results from ARRCOM project 6783901 and Navy Manufacturing Technology project DNA 475 provided the basis for this project.[1,2]

These two earlier programs also dealt with fineblanking fluidic laminates and were coordinated by HDL personnel. In this MMT program, a fluidic laminar proportional amplifier (LPA) design with a nozzle width of 0.5 mm (0.020 in.), in HDL's standard format, was chosen to be fineblanked along with a vent plate for this LPA and a dropping resistor with a 0.5-mm (0.020-in.) nozzle. All these elements were considered critical for achieving repeatable performance in fluidic circuits using these (and other) components. All parts were fineblanked from 347 stainless steel.

Before the full run of LPA parts was made, an initial lot of about 100 laminates was fineblanked, and performance curves were run on samples from this lot. The fineblanking die was then modified and subsequent parts were retested iteratively, until the desired performance was achieved. The prescribed quantities of LPA's were then produced.

[1] *Lester Pecan, Fineblanking, Diffusion Bonding, and Testing of Fluidic Laminates, Tritec, Inc., Columbia, MD, under contract to Harry Diamond Laboratories, HDL-CR-80-074-2 (July 1980).*

[2] *L. E. Scheer, J. S. Roundy, and J. W. Joyce, Manufacturing Techniques for Producing High Quality Fluidic Laminates in Production Quantities, Proceedings of the 20th Anniversary of Fluidics Symposium, ASME (1980).*

Testing indicated that the LPA performance was consistent with the result obtained in Navy project DNA 475: the LPA gain and performance repeatability from laminate to laminate were good. LPA gain was generally better than that of the LPA's from MMT project 6783901. This improvement is attributed to minor design changes, aimed at enhancing tool life at some expected compromise in performance, that were incorporated into the LPA design used in 6783901. No such changes were made in DNA 475, and results verified that they were not necessary; consequently, no variations from the standard LPA were made in this project.

Limited testing of vent plates and dropping resistors also showed acceptable performance and good laminate repeatability. Overall, the results of this project supplement those obtained from the other two manufacturing projects cited.

Thick Film Facility. A thick film facility was established to validate technical data packages that contain hybrid microelectronic subsystems. The need for validation surfaced when prototype hybrids were released for production, and these designs were found to be not readily adaptable to existing high-volume production techniques. This lack of producibility has resulted in loss of time and money because of the need to redesign hybrids for production.

To validate future hybrids for commercial producibility, production-grade thick film processing equipment has been assembled at HDL to simulate production rates on new prototypes, thus adding the feature of mass producibility to thick film technical data packages.

This validation facility currently includes thick film printers, furnaces, a high-speed laser trimmer, an automatic parts placer, and an automatic wire bonder. These primary pieces of production equipment are currently being used to establish producibility for prototype hybrids for the anti-radiation projectile program. Training of personnel is continuous so that production rates will be representative of what is achievable in industry.

Ceramic Metal Substrates for Hybrid Electronics. Thick film circuitry is extensively used in artillery, mortar, and rocket fuzes and is planned for small-caliber fuze applications. In general, the thick film circuitry can be characterized as low-cost, high-volume electronics that can survive the extremely rugged gun environment.

Thick film circuitry is currently constructed on brittle ceramic substrates. In order to survive gun firing, these substrates must be adequately backed by a metal support structure fixed to the fuze housing. The elimination of this metal support structure could result in a substantial cost savings in many hybrid applications. Ceramic-coated metal substrates can be substituted for both the support structure and the ceramic substrate. The problem with this substitution is the lack of production techniques needed to insulate the metal and to fabricate the electronics on the insulated coating. The MMT program aims to establish techniques needed to coat metal substrates and built thick film circuitry on coated metal substrates.

The MMT program at this date is approximately 50 percent completed. Work completed includes the characterization of the coated materials and detailing of various coating techniques. Ongoing is the review of existing thick film processes needed to fabricate electronics on insulated metal substrates.

The end products of this MMT program include a handbook on using ceramic metal substrates in ordnance work and a pilot run of substrate fuze electronics depicting those manufacturing methods established during the program.

Transducer Processing Technology for Microwave Delay Lines. The production of microwave acoustic delay lines (MADL's) scheduled for several Army systems caused concern because of low yields and poor delivery. An MMT program was established to improve the yield of the zinc oxide (ZnO) processing, which is the key process. The goal of this effort was to raise the yield of the piezoelectric ZnO transducers from less than 10 percent to more than 50 percent.

The three sputtering parameters considered to be most important (argon-oxygen ratio, sputtering pressure, and substrate temperature) were individually varied in a 3 by 3 matrix of experiments to find processing plateaus. In addition, the original starting-point parameters were repeated every fourth run as a control.

The results of these experiments indicated that a 75-percent argon/25-percent oxygen mixture at 20 or more micrometers of mercury pressure would produce good ZnO transducers. The temperature did not appear to be an important parameter. In addition to these findings, it appears that a "memory" exists between runs and a lengthy oxygen clean-up is required to condition the ZnO target and "erase" the memory.

The primary goals of this program have been achieved and the process now has ZnO yields from just over 50 percent to as high as 80 percent. These yield figures are for 4.0-GHz transducers. The next phase of the program is to extend the frequency range to 10 GHz. This MMT program was carried out at HDL and at the contractor, Westinghouse, Baltimore.

Photolithographic Equipment for Small-Geometry Semiconductor Devices. One current MMT program on small-geometry semiconductor devices has the goal of developing a prototype optical wafer stepper direct-step patterning system and the associated technical data package. The equipment developed for wafer patterning was delivered during May of 1981. The acceptance tests of the system have indicated that all design criteria for the system have been achieved. The wafer-patterning system will continue to be used to fabricate devices with submicrometer geometries using multilevel resist technology to extend the capabilities of optical systems to fabricate high-density integrated circuits using submicrometer feature sizes.

Mechanical Joining of Miniature Electronic Components. In order to use laser welding to join miniature electronic components used in fuze fabrication, it is necessary to develop and document the processing parameters. A laser welding system and the associated data package to allow welding the M732 battery were developed. Problem areas encountered in the welding process were documented, as well as suggested battery

modifications to enhance successful laser fusion welds. Laser welds were successfully made on the braking fins required on the anti-radiation missile. Additional applications for laser welding will be supported and documented as they are successfully accomplished.

Simulation and Testing

Computer Simulation. The HDL Master Systems Controller (MSC), a DEC VAX 11/780 virtual-memory minicomputer, received extensive use over the past year in a variety of simulation activities. The system has averaged over 1,000 man-hours per month of terminal usage (fig. 8), and the CPU time has ranged between 150 and 650 hours per month. The system was augmented in the fourth quarter of FY 81 by the addition of two megabytes of main memory, raising the total to 2 3/4 megabytes. The augmentation significantly reduced the system response time and allowed more simultaneous use of the machine.

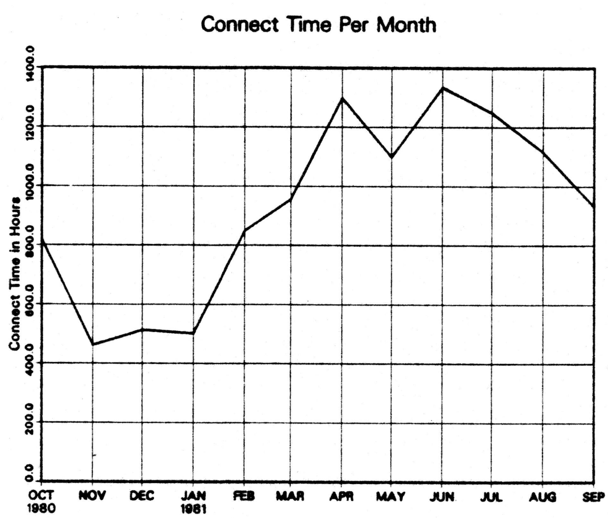


Figure 8. Use of simulation system.

An additional aid to simulation was the move of the Adage GP-430 three-dimensional graphics system from the PDP 11/45 to the VAX. This enabled the virtual memory of the VAX system to be used in the development of the graphics simulations done on the Adage. This also sped up the analysis of field-test film data using the Adage system, enabling over 100 films to be processed.

One of the major problems addressed this year was the requirement to display both computer-generated text and graphics simultaneously. This is a requirement not only in simulation applications but in the entire computing environment. Recognizing this problem, HDL began work on a project, sponsored by DARCOM and the Mobility Equipment Research and Development Command (MERADCOM), called TIGER (Text Integrated with Graphics Environment Resource). This work will provide a bridge between existing graphics and text-editing programs and allow their outputs to be combined into a single "picture" which has both text and graphics.

A program, PRIMENET, was developed and incorporated in the MSC and the SPEAR PR1ME computer. This allows programs and data to be rapidly and easily transferred between the MSC and the three PR1ME computers on the SPEAR network, using data communication lines rather than magnetic tapes, which require manual intervention.

A system for tracking the status of projects in the machine shop was developed and implemented this year. This system, operating on the MSC, enables the shop management to immediately determine the status of a job and better manage the resources expended on a project.

A major Patriot-related project that used the MSC was the development of the software for the Patriot fuze tester—the Army factory acceptance tester (AFAT). Most of the software was developed on the MSC, cross-compiled, and down-line loaded to the tester. A number of software configuration-management utility programs were developed on the MSC and used on this project.

Ballistic Simulation. HDL has a highly instrumented laboratory facility for ballistic simulation, to test fuzes or other components expected to perform or survive in a high-g environment. Simulators reproduce mortar, artillery, and short-tube rocket environments. Testing this year supported many HDL programs on tube-launched fuzes as well as programs for ARRADCOM, MICOM, and Naval Avionics Command.

3-in. Gas Gun Artillery Simulator. This simulator provides an artillery environment in the laboratory for testing fuzes and fuze components. It can produce angular acceleration and setback forces followed by constant angular rotation. Previously, tests were conducted at a maximum rotational rate of 150 rps; new drive motors and a new equipment configuration permit rotational rates as high as 300 rps. This permits testing of complete conventional fuzes in the angular acceleration environment of the 155-mm gun.

Instrumentation Improvements. Setback simulation is accomplished during impact of a projectile (carrying the test sample) with a crushable momentum exchange material. The projectile is photographed with a streak (rotating-drum) camera. Camera coverage is limited by the length of the projectile as it enters and leaves the camera field of view. Recent increases in simulation capabilities have resulted in longer pulse durations. Therefore, in many tests, the stopping distance is long compared to the projectile length, and only a portion of the setback simulation is photographed. To solve this problem, HDL devised an optical plane mirror system, which doubles streak camera coverage. The camera photographs two positions along the trajectory simultaneously; at each position, coverage is just as large as it is without the mirror system. Furthermore, the two fields of view may be separated from 3.5 to 18 in. between centers. The mirror system was specifically designed for cameras used with the 7-in. air gun and the setback-drag simulator.

Rotating-drum cameras employ a strip of film wound inside the film drum, so that the film is in the form of a cylinder when the picture is taken. The event being photographed is not synchronized with the camera, and it often happens that the streak image spans the junction of the two ends of the film. When this occurs and the film is unrolled and processed, the streak image is found to be at the extreme ends of the film strip with blank film in between. Because such films are too long to fit completely into the microdensitometer (used for data analysis), some data are lost and much time is wasted in scanning and analyzing the blank area between the two areas of interest. Attempts to cut and splice the film so that the streak image is continuous along the time axis result in discontinuities along the displacement axis or angular misalignment along the time axis; this introduces large errors in projectile acceleration and velocity. A film-splicing jig was developed to accurately align and hold the two pieces of film while the two ends are securely joined. Film analysis now produces contINOUS data, devoid of spurious variations due to the splice.

Environmental Simulation. The HDL Environmental Technology and Test Branch is equipped to simulate shock, vibration, and various climatic conditions encountered by military ordnance during shipping, handling, and storage, and in tactical environments. Additional capabilities include tensile testing, shock-spectrum testing, transient-waveform analysis and synthesis, structural dynamic simulation using computer models, and modal analysis. These environmental capabilities support the following missions and the functions listed in table 3. Table 4 shows the variety and type of test and engineering services that have been rendered for each of the indicated HDL test programs. Figure 9 shows the ROLF (Roland fuze) test article mounted on the vibration slip table while undergoing a series of environmental qualification tests.

Table 3. Test Service Support by Type

Test/service	Application
First-article approval testing	Production
Engineering development	R&D
Engineering control samples	Production
Stockpile reliability	Production
Design validation	Qualification
Fixture and instrumentation system design	R&D/production/qualification
Certification and calibration	R&D/production/qualification
Test plans/specifications/ reporting	R&D/production/qualification

One of the ROLF tests called for 300 rapid repetitive shocks at intervals of 1 to 3 shocks per second. These requirements exceeded the capabilities of the free-fall shock-impact test

Table 4. Test Service Support by Program

Project	Shock	Vibration	Temperature	Altitude	Humidity	Salt	Other
M817	X	X	X	—	X	X	—
Hand-cranked generator	—	X	X	—	—	X	—
Sea Gnat	—	X	—	—	X	—	—
Viper	—	X	—	—	—	—	—
MLRS	X	X	X	X	X	—	—
AN/145-TPD	X	X	X	X	X	X	Fungus, handling, loose cargo
HATS	—	—	—	—	—	—	Tensile test
M732	—	X	—	—	—	—	—
M734 altimeter	—	—	—	—	X	—	—
GSRS (S&A)	—	X	X	—	—	—	—
Patriot	X	—	X	—	—	X	—
Patriot Raytheon	—	X	—	—	—	—	Response of fuze in missile
Encapsulant	—	—	—	—	X	—	—
UEJ	X	X	—	—	—	—	Strain
PS416	—	—	—	—	—	—	10-ft drop
Honeywell	X	X	—	X	—	—	—
Generators	—	—	—	X	—	—	—
ROLF	X	X	X	X	—	—	—

machine on which all shock tests are normally performed. However, it was executed with relative ease on the vibration table with the GenRad Digital Control Test System's transient waveform control program.

The branch personnel were involved with the Patriot limited-environment test conducted at the laboratories of Raytheon Corp., the missile system prime contractor. This test was designed and instrumented to determine whether certain electronic assemblies within the fuze were being subjected to excessive resonant vibration levels during a normal production vibration test. This branch

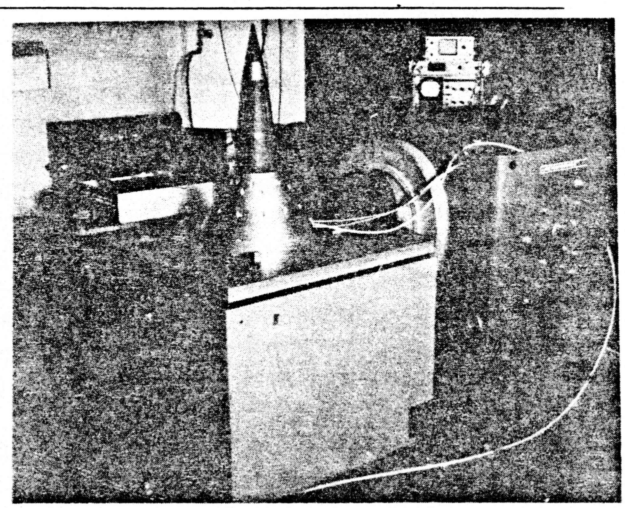


Figure 9. Roland fuze test article driven by shaker-actuated slip table.

calibrated the vibration test equipment, recorded the test runs on magnetic tape, and electronically analyzed the test signals.

Tests on the unattended expendable jammer (UEJ) involved tensile testing many sample ribbons of Kevlar to determine whether they would withstand the centrifugal force in an actual operation. Kevlar is the material from which the deceleration sling is fabricated.

Extended temperature-humidity tests were conducted on a large sample of encapsulated circuit boards to evaluate the effectiveness of various encapsulating materials.

Additionally, environmental testing was provided for HATS, M817/TDD, M732, M734, M587, Viper, AN/145 terminal protection device (TPD), Sea Gnat, SMAW, MLRS, and the G-76 hand-cranked generator.

Field Operations. The HDL field operations section field tests all types of HDL-developed fuzes, associated explosive devices, fuze power supplies, and electronic rf telemetry systems. Field-test equipment includes telemetry vans, a telemetry data-reduction ground station, high-speed cameras, film analyzers and data-reduction devices, explosive loading facilities, explosive environmental temperature-conditioning chambers, drop towers, an air-target encounter facility, and other necessary test equipment at the HDL test area at Blossom Point, MD, and at Adelphi, MD. Tests performed at the HDL test area this year include

firing, recovery, and disassembly of explosive-loaded projectiles and fuzes for rockets, mortars, and cannons up to 106 mm in caliber,

encounter facility fuze tests for various projects,

Air Force drops,

Navy Sea Gnat engineering test firings,

Navy mine sweeping,

jammer helicopter drops,

electrostatic fuze engineering tests,

M734 fuze engineering tests,

M724 fuze engineering tests,

SMAW engineering tests, and

trough inert firing and recovery for hardware investigation.

At Army proving grounds (Yuma, Aberdeen, Jefferson), HDL conducted or participated in numerous ordnance test programs this past year:

M732 fuze lot acceptance and engineering development firings,

M734 lot acceptance and VECP (value engineering change proposal) firings

M724 engineering development and first-article firings,

XM749 engineering development firings,

M735 new material stockpile test and joint test unit firings,

jammer engineering development tests,

MLRS engineering development tests, and

numerous other short-duration tests.

These tests ran from several days to six weeks and required from two to eight field operations personnel to process test items and operate the data-acquisition equipment.

Major improvements include the procurement of a new telemetry data-acquisition van and associated instruments to support all HDL fuze projects, as well as the activation of two ammunition magazines and a weapons storage building at the HDL test area.

Product Improvement

Material Testing Technology (MTT) Program: Piston Actuator Tester. A new method of measur-

ing the performance of explosive piston actuators has been devised and is being implemented for production use under this MTT project. The concept is to directly drive a weight with the piston and to measure the acceleration and energy imparted to the weight. Accelerometer traces are displayed on a waveform-processing digital storage scope. The scope automatically double-integrates the acceleration versus time trace to provide displacement versus time, and then displays these two traces against each other to provide a force versus displacement plot, as required for accurate performance evaluation. The integral of this plot, which is the total energy, can then be correlated against the total energy measured directly from the spring compressed in stopping the weight. The force and energy parameters are used to evaluate the performance of the actuator. An apparatus and an instrumentation system have been designed and built. They are configured for ease of use in a production environment to better insure product quality wherever piston actuators are used.

Product Improvement Program for M734 Turboalternator. The object of the product improvement program (PIP) for the M734 turboalternator is to replace the present stator material (permalloy) with a less costly material, such as silicon steel, from which the end plate and housing that make up the stator can be stamped.

During previous years of the program, the feasibility of using the new material was demonstrated through laboratory tests of various candidate materials, coatings, and annealing processes to achieve the best balance between permeability and hardness.

A field test was conducted during the past year on nickel-coated electrical steel alternators that were assembled into fuzes by the contractor. They were fired at the extremes of the gun environment. The high scores achieved demonstrate that the coated material is a suitable substitute for permalloy, which costs 10 times as much. The coated electrical steel withstands the gun environment and provides adequate voltage for the fuze.

Accelerated storage tests have shown that electroless nickel coating on the silicon steel is sufficient to prevent corrosion of the stators while providing the required electrical output.

Turboalternator Power Supply for Artillery Fuzing. To pursue potential cost savings, HDL researchers designed a turboalternator to provide power to an artillery fuze. As distinct from the turboalternator employed with the M734 mortar fuze, the artillery version must survive much higher setback forces and air velocity as well as withstand high levels of spin. Consequently, the stator and rotor are of smaller diameter and lighter, the alternator employs precision bearings, extra shaft support is provided, and aerodynamic speed-limiting features were used with the nylon turbine and air inlet.

Two field tests verified the gun ruggedness of the alternator and its ability to survive high muzzle velocities. In one test, alternators were fired from a 75-mm pack howitzer at 17-kg setback and 15,000 rpm spin rate. Telemetered performance data verified the expected speed regulation and voltage level in flight. In another test, several alternators were flown on Zuni rockets that achieved a burnout velocity of 2,700 ft/s (800 m/s)—comparable to artillery velocities. The alternators operated satisfactorily throughout the flight.

Laboratory tests have shown that a slightly larger design to accommodate more magnetic material resulted in a fourfold increase in output power with only a 33-percent increase in alternator diameter.

nuclear weapons effects

Lead Laboratory for Nuclear Weapons Effects

HDL is the DARCOM Lead Laboratory for Nuclear Weapons Effects Technology. In this capacity, HDL plans, coordinates, and manages the DARCOM nuclear weapons effects (NWE) program within ERADCOM and other DARCOM research and development (R&D) commands. The program's goal is to assure the overall survivability of critical Army materiel in the environments created by nuclear weapons; this program must be responsive to the general needs of the Army and make the best use of existing technical resources. To accomplish these program objectives, HDL coordinates closely with the following organizations: DA staff, HQ DARCOM, the Training and Doctrine Command (TRADOC), the Army Nuclear and Chemical Agency (USANCA), Army Program/Project/Product Managers (PM's), DARCOM R&D commands and performing laboratories, and DoD agencies such as the Defense Nuclear Agency (DNA) and the Defense Communications Agency (DCA) HDL also coordinates with the other services, the Department of Energy laboratories, and various industrial and academic organizations involved in the NWE area.

Major managerial accomplishments this year include the following:

- HDL provided a member to the Panel of Experts on EMP and NWE of the NATO Army Armaments Group.

- HDL briefed DNA personnel on Army requirements and plans for a large-area blast/thermal simulator and discussed design concepts for such a simulator, which could expose large targets such as tanks to threat-level blast/thermal nuclear environments. Plans were coordinated for a joint DNA/HDL program.

- HDL provided the alternate Army/DARCOM member for the Joint Logistics Commander's (JLC) Panel on Logistic Support of Nuclear Hardened Systems, a subpanel chairman, and members for three subpanels.

- HDL provided the Army Technical Project Officer for French and German NWE Data Exchange Agreements (DEA's). The French DEA has been updated, and preliminary steps were initiated for a DEA with the Netherlands.

- HDL continued joint program efforts with the U.S. Army Communications Command to address hardening of satellite terminals.

- HDL completed an Army program plan for the development of the large blast/thermal simulator. The plan was coordinated with DNA, and a joint program initiated.

- HDL provided a briefing to MG Boyle, Director of Combat Developments, HQ TRADOC, on basic EMP atmospheric test data and associated EMP equipment hardening issues.

- HDL provided a briefing to Ballistic Missile Defense System Command (BMDSC) and DNA representatives on source-region simulation recommendations for low-altitude defense systems.

• HDL is presently participating in the DoD-sponsored SGEMP (system-generated electromagnetic pulse) working group as the Army representative.

• HDL continues to provide the Deputy Chairman for the Nuclear Survivability Committee Secretariat (NSCS) and additional members as required.

• HDL provided a briefing on the overall HDL NWE technology program to MG N.J. Fulwyler, Director of the Nuclear and Chemical Directorate, under the Deputy Chief of Staff for Operations and Plans, and to representatives of the Director of Combat Support Systems, under the Deputy Chief of Staff for Research, Development and Acquisition.

• HDL assisted HQ DARCOM in the presentation for the Second Nuclear and Chemical System Program Review (SPR), In-Process Review (IPR), given to Gen. J.W. Vessey, Vice Chief of Staff, U.S. Army.

System Vulnerability Assessment and Hardening

The focus of the HDL NWE effort is the vulnerability assessment and hardening of critical military tactical and strategic systems. The work is performed under projects funded by the Army, DCA, DNA, and other agencies and is directed at increasing the survivability of these systems, in various combinations, to all NWE, including electromagnetic pulse (EMP), transient-radiation effects (TRE), system-generated EMP (SGEMP), thermal radiation, blast, and fallout.

Assessment and Hardening for EMP

Multiple Systems Evaluation Program. The basic goals of the Multiple Systems Evaluation Program (MSEP), which have been accomplished, were (1) to formulate recommendations or design guidance for high-altitude EMP (HEMP) protection of fielded critical Army systems and (2) to provide generic HEMP hardening technology for hardening of critical development systems. The critical systems included nuclear delivery systems and command, control, and communication (C^3) systems. In prior years, assessments were made of the Pershing, Lance, M-109, and M-110 nuclear delivery systems and associated single- and multichannel communication systems. Hardening fixes for certain systems that were found to be vulnerable are currently in progress or have been completed.

Research continues to develop advanced analytic and testing capabilities in the nuclear survivability area; these advances are used for nuclear vulnerability assessment and hardening studies of selected critical Army equipment and systems. Such assessments are under way or planned in the mission areas of air-defense systems; intelligence, surveillance, and target-acquisition systems; and automatic data-processing systems.

Multiple Launch Rocket System (MLRS) Electronic Time Fuze. An analytical assessment of the vulnerability of the MLRS electronic time fuze, an HDL-designed item, was completed in FY 81. The results were used to avoid potentially costly changes in system design and to support a preliminary full-system field test. A document has been prepared detailing the characteristic response of the fuze and fuze-system interfaces to EMP and has been made available to all MLRS program participants.

Evaluation of Component Degradation for EMP Vulnerability Assessment. The computer studies of the basic physical processes involved in the initiation of second breakdown in silicon diodes have been extended to several new areas. For example, calculations of high current characteristics of Si resistors ($P^+P\ N^+$ or $N^+N\ N^+$) and two-terminal transistor-like devices (PNP or NPN) have shown contrasts to both forward- and reverse-biased junction diodes ($P^+P\ N^+$ or $N^+N\ P^+$). A newly discovered transition point in the forward-biased junction has been verified experimentally and promises to provide data on the previously unmeasurable depletable width of a diode, an important parameter in the second breakdown of the reverse-biased diode.

A new and extensive study has been initiated on the dependence of the surge resistance of the reverse-biased diode upon doping level and width.

Defense Communications System Survivability. DCA has tasked HDL to develop a handbook of HEMP design practices which will be used to enhance the survivability of the future Defense Communications System (DCS). These practices are based on the results of previous system assessment and hardening projects performed by HDL. As indicated in the FY 80 ERADCOM Posture Report and HDL Laboratory Review, HEMP hardening design practices were being evaluated in the Generic Verification Facility (GVF) at HDL's Woodbridge Research Facility. These experiments were completed. The results of the experiments and previous HDL test and analysis activity were used to formulate a handbook for the sponsor. The handbook was based on an allocated hardening approach over zones of application for fixed facilities. Unique sponsor requirements such as equipment transportability dictated an approach that was novel and diverged from standard hardening practices. HDL has provided the sponsor with drafts of the handbook. The draft was accepted and the final document is being printed.

Defense Satellite Communication System. The Defense Satellite Communication System (DSCS) is that part of the Defense Communication System which provides point-to-point communication paths through a set of synchronous satellites and earth terminals. The earth terminals range in size and capacity from mobile, shelter-mounted, tactical terminals located on the tactical battlefield to large fixed facilities. The survivability of these terminals to HEMP is of extreme importance. They provide key communication links in response to a nuclear attack.

HDL has been tasked by the U.S. Army Communications Command to provide technical data and management data packages (TDP's and MDP's) for the retrofit hardening of selected AN/FSC-78 heavy terminals and AN/GSC-39 medium terminals. HDL has chosen TRW, Inc., to develop TDP's and MDP's. HDL is providing the program management and the technical expertise for the selection of cost-effective hardening approaches. As part of the evaluation of cost-effective techniques, the GVF at the Woodbridge Research Facility has been converted to a satellite terminal test bed. Figure 1 shows the GVF in its newly configured state. In the left foreground is an AN/GSC-39 medium terminal antenna assembly. The U.S. Army Satellite Communications Agency (SATCOMA) provided the system to HDL for the assessment and hardening program. Behind the structures is a second terminal dish. This is a 1/3-scale model of the AN/FSC-78 antenna. These antennas are connected to the structures on the concrete pad by cable trenches. To the right can be seen the HDL Repetitive EMP Simulator (REPS) and in the far background is the Vertical EMP Simulator (VEMPS). Testing on these structures was initiated in the last quarter of FY 81.

HDL is addressing many key issues in this program. Issues such as communications disruption, life-cycle costs, configuration management, application of scale modeling, confidence in approaches, best shielding options versus total lifetime cost, and hardness verification are the subject of much discussion and evaluation. In most of these areas, the state of the art is being stretched. In many ways the program is a pilot activity that may determine the Army's, if not the country's, future HEMP hardening activities.

XM2/3 Infantry/Cavalry Fighting Vehicle. The XM2/3 Infantry/Cavalry Fighting Vehicle (IFV/CFV) was tested to the simulated EMP environment at the Woodbridge Research Facility. This test was part of a broad study to determine the inherent survivability/vulnerability of the vehicle. Data gathered on cables leading to mission-critical circuitry were used to make quantitative assessments of circuit survival. Reports and recommended action have been prepared for the PM IFV/CFV and will be published in FY 82.

EMP Effects on Satellite Communications Terminals. HDL briefed SATCOMA on the EMP requirements for the latest generation of tactical satellite communications terminals. After the briefing, a memorandum of agreement was produced in which HDL was given responsibility for evaluating the susceptibility of these terminals to nuclear EMP.

Multichannel Radio Surge Arresters. The F-1538/G binding-post surge arrester, with extremely wide applicability in military equipment, was certified in tests at Tobyhanna Army Depot.

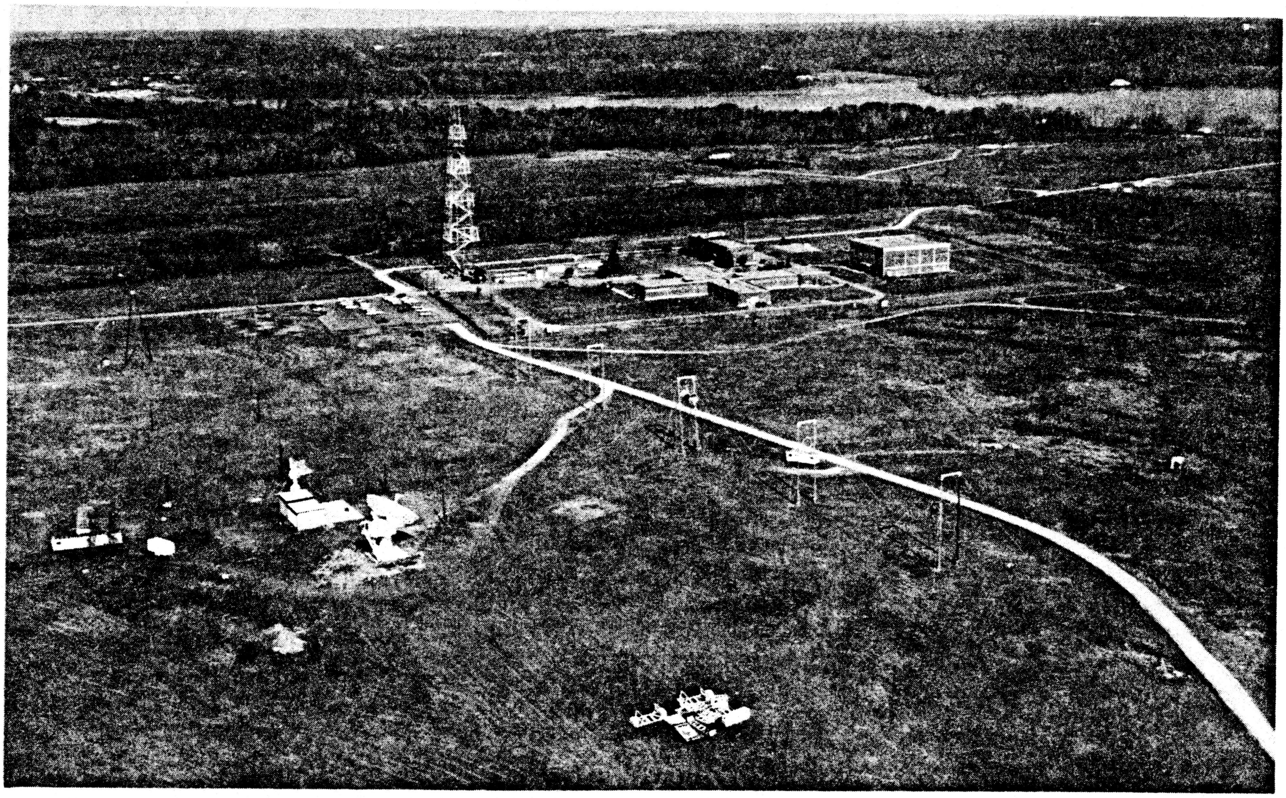


Figure 1. Satellite-terminal configured GVF shown with REPS and VEMPS at Woodbridge Research Facility.

These tests are conducted at the depot rather than at HDL to minimize the impact on delivery schedules of the communication systems. A military specification has been drafted and is currently under review at Fort Monmouth.

A surge arrester for installation in existing carbon-block lightning-arrester mounts has also been certified. Designated the F-1537/G, this arrester is simply a screw-in replacement.

Assessment and Hardening for TRE

One objective of the program on transient-radiation effects (TRE) vulnerability and hardening is to evaluate the vulnerability of critical Army electronic equipment to the initial radiation, neutrons, and gamma rays of the tactical nuclear threat. In support of this objective, methods are developed, supporting documentation is drafted, and the TRE on piece-parts, circuits, and systems are determined. The evaluation of system nuclear response draws on semiconductor manufacturers' piece-part performance data, circuit design parameters, the Component Response Information Center (CRIC) data bank, and analysis methodologies which have been developed. Where necessary, the data are supplemented by piece-part or circuit testing in appropriate simulation facilities. The system response information is presented in a form most useful for PM's, in war gaming, and for the Army tactics and doctrine community. In addition, hardening measures are recommended to the developing or managing agency wherever vulnerabilities are uncovered.

Radiation Effects on Fiber Optics. The effects of steady-state ionizing radiation on the attenuation of glass-clad fiber-optic waveguides were studied as a function of wavelength (0.8 to 1.5 μm) and temperature (−50° to 70° C). Fiber constituents included Ge, P, F, B, and high- and low-OH synthetic fused silicas. Means were investigated by which the radiation-induced loss may be reduced. For operation in the near-infrared (0.82 μm), reduced radiation losses occurred with certain doped (Ge-P) silica-core fibers and with high-OH Suprasil silica-core fibers that have a plasma-deposited fluorine-doped silica cladding. Further reductions in the radiation response were observed by operating in

the 1.3- to 1.5-μm range, with Ge-doped silica-core fibers (fabricated by the modified chemical deposition process) showing the lowest losses. For a 2,000-rad(SiO_2) ^{60}Co irradiation, the magnitude of the radiation losses at 1.3 μm was 12 dB/km at −50° C. Even lower losses were observed at 1.5 μm.

Thermal Radiation Effects on Wire and Cable Jackets. The damage to common electrical wire and cable caused by exposure to thermal radiation pulses at the White Sands Solar Facility (WSSF) included breaching of the insulating jacket (bare metal visible) and the electrical short circuiting of conductors. Black polyethylene jackets (0.4 mm thick) were found to be the most susceptible; breaching occurred around 30 cal/cm^2 and short circuiting occurred around 60 cal/cm^2. Breaching of colored Teflon jackets (0.2 mm thick) occurred around 90 cal/cm^2, while uncolored Teflon was not affected up through 175 cal/cm^2. Thick (>1.7 mm) polyvinyl chloride and rubber jackets were not breached up through 200 cal/cm^2, although they were scorched and lost about half of their thickness. For constant fluences, variations in flux and pulse width did not affect observed damage. Damage data were obtained also for quartz lamp and carbon-arc radiation. A comparison of damage data suggests that the reflectivity of electrical insulation increases significantly in the infrared region.

Ionization of SiO_2 by Single Heavy Charged Particles. Highly ionizing heavy charged particles generate significant charge as they pass through the thin thermally grown gate oxide of a metal-oxide-semiconductor field-effect transistor (MOSFET) device. The amount of charge created by an alpha particle and proton has been calculated from the energy loss per unit path length for the particles and the ionization energy of the silicon dioxide thin film.

The number of electron hole pairs escaping initial recombination is determined experimentally for the alpha and proton irradiations and the results are explained in terms of the columnar recombination model. The equation orginally presented has been solved exactly for these conditions using a finite-difference code. A comparison of the theory and experimental results shows that the charge interactions in the dense ionization track can be well described by a model which includes diffusion, drift, and recombination in a dense column of charge which has an initial radius of 4 nm.

The MOS samples were irradiated under positive bias at approximately liquid nitrogen temperature (~77 K). The samples were irradiated at low temperature because it has been shown that at low temperature the hole mobility is much less than the electron mobility. Even at 77 K, the electrons are swept out of the oxide almost instantaneously. Thus, after a few picoseconds, only the positive charges that have escaped recombination remain, and they are frozen in place for long times compared with experimental time measured. The yield of charge has been shown to be much less than the values reported for other types of irradiation. For an alpha particle irradiation with a field of 1 MV/cm across the SiO_2, only 7 percent of the initial charge created escapes recombination.

The conclusion from these experiments is that threshold voltage shifts induced in submicrometer-dimension devices are not likely to be a problem until device dimensions are less than 0.5 μm. The effects of the charge clusters could be a problem, but it should be kept in mind that in these calculations 100-percent hole trapping has been assumed. If hardened oxides were used, the effects would be reduced by another factor of 10.

Annealing of CMOS Devices: Implications for Test Procedures. An understanding of the mechanisms involved in the recovery or anneal of a complementary MOS (CMOS) device following exposure to ionizing radiation is essential in the proper design of test procedures and for the prediction of device response at times and in environments of interest. This year, researchers at HDL examined the short- and long-term recovery of radiation-induced flatband-voltage shift for both Al- and Si-gate MOS capacitors following pulsed electron-beam irradiation; the results of these experiments were interpreted in terms of their significance for the design of test procedures. The short-term anneal was found to be similar for both Al- and Si-gate capacitors. While Al-gate capacitors exhibited a long-term annealing behavior with a simple $\ell n(t)$ dependence, certain Si-gate capacitors had a more complicated annealing response due to the

presence of interface states and/or lateral nonuniformities (LNU's). Experiments designed to investigate the dependence of the long-term anneal on oxide thickness, temperature, and bias were also performed. It was seen that thinning the oxide dramatically reduces the effects of interface states and LNU's on the long-term anneal. The long-term annealing response for capacitors where the effects of interface states and/or LNU's were small had a weak temperature dependence (−60° to 100° C), indicating that the removal of bias following irradiation does not drastically affect the anneal. On the other hand, the long-term annealing response for capacitors where there was a significant buildup of radiation-induced interface states and/or LNU's exhibited a stronger temperature and bias dependence and illustrated the importance of maintaining bias at all times following irradiation.

Component Response Information Center. Nuclear vulnerability data on semiconductor devices are necessary for the design of components for a given initial nuclear radiation specification, for the assessment of the vulnerability of inventory equipment, and for hardness assurance studies. Since nuclear response testing is expensive and time-consuming, it is important that the results of all tests be disseminated as widely as possible; such dissemination can eliminate redundant testing efforts. In recognition of this need, a data base of radiation-effects data on semiconductors is maintained at HDL. Both actual data and a bibliographic reference file are available.

Assessment and Hardening for All Effects

Nuclear Weapons Effects Survivability—Data Base for Common-Use Equipment. HDL has developed a computerized data base which contains a listing of common-use equipment (CUE)[1] associated with the tactical systems performing critical battlefield missions—such as nuclear delivery, air defense, combat support, C^3, etc. The information in the data base can be used to compare system NWE survivability criteria to those of the supporting CUE; this comparison will permit easy identification of incompatible criteria and system survivability problems. CUE includes those items which are ancillary to more than one tactical system; for example, mobile electric generators, trucks, electrical and electronic shelters, and radios are CUE. The data base now includes all materiel that supports five critical field-artillery systems—Pershing 1A and II, Lance, the 155-mm self-propelled (SP) howitzer, and the 8-in. SP howitzer—and that which supports an ISTA battalion. A report has been published that includes the program concept, the critical equipment list, the cross-reference data bank, and a user's guide, which contains a set of instructions for using the computer program.

[1] *S. Bukalski and W. Vault, Nuclear Weapons Effects Survivability Data Base for Common-Use Equipment: Program Concept and User's Guide, Harry Diamond Laboratories, HDL-SR-81-2 (June 1981).*

Hardened Tactical Shelter (HATS) Program. The HATS Project Office is developing a family of shelters providing a hardened complement to the current S-250 and S-280 electronic equipment shelters. This family of shelters is being designed for protection of electronics in C^3 systems and in surveillance and target-acquisition systems.

The HATS accelerated engineering development program is into its second year, and the hardened shelters have met or exceeded their critical survivability objectives. Figure 2 shows the Model T shelter, with its tiedown system and integrated NBC (nuclear, biological, and chemical effects) enclosure. The unique construction, using a composite Kevlar, aluminum, and honeycomb wall and Kevlar pultrusion structural members, will stop 60-grain (3.9 g) fragments traveling at velocities of almost 500 m/s. The shelter system will survive thermal and blast effects at levels of approximately 65 cal/cm^2 and 10 psi, respectively. Figures 3 and 4 present the unique structural design and fabrication techniques which allow the hardened shelter to meet its severe survivability requirements. Figure 3 is a wall cutaway view showing the Kevlar laminated skins, the honeycomb core, and the Kevlar pultrusion (spaced at 22-in. intervals). Figure 4 shows a typical panel corner joining technique. The HATS wall design provides the required fragment and nuclear thermal/blast protection at a fraction of the weight of a conventional aluminum or steel design.

HATS is presently completing its test and evaluation phase on four type A (S-280 size) shelter

prototypes and three type B (S-250 size) shelter prototypes. The test program includes the usual MIL-STD tests (transportability, mechanical, environmental, etc) as well as ballistic and unique simulated nuclear blast, blast/thermal, and EMP tests. Figures 5 and 6 show the before and after condition of one of the two type A shelters which were placed on the MILL RACE high-explosive event in New Mexico. The shelter on a 2-1/2 ton truck shown was exposed at the 6-psi blast level and 40-cal/cm^2 thermal level. The thermal environment is supplied by a liquid oxygen/powdered aluminum thermal radiation source (TRS). For comparison, figure 7 shows a standard S-280 shelter, with a severe wall failure after exposure to only 4.5 psi and 40 cal/cm^2. The second type A shelter was exposed to 9 psi (fig. 8). All MILL RACE test results were positive.

The second phase of the simulated nuclear blast test was conducted in the Large Blast Shock Tube (LBS) at Gramat, France. This unique facility provided a controlled, long-duration, blast test of the complete shelter/truck combination. Figure 9 shows the test section. The LBS sequence included a preliminary test event at 3.5 psi and two tests at 10 psi. The hardened shelter passed the tests successfully.

MIL-STD testing of HATS is under way at the prime contactor's facilities (Craig Systems) in Lawrence, MA, and at the U.S. Army Test and Evaluation Command's Aberdeen Proving Ground (APG). The EMP testing of the hardened shelter is under way at the Woodbridge Research Facility. The EMP tests are part of a combined analysis and experimental program which addresses seam and door impedances, shelter shielding effectiveness, and the design of shelter electrical entry panels providing good EMP design practices for system applications.

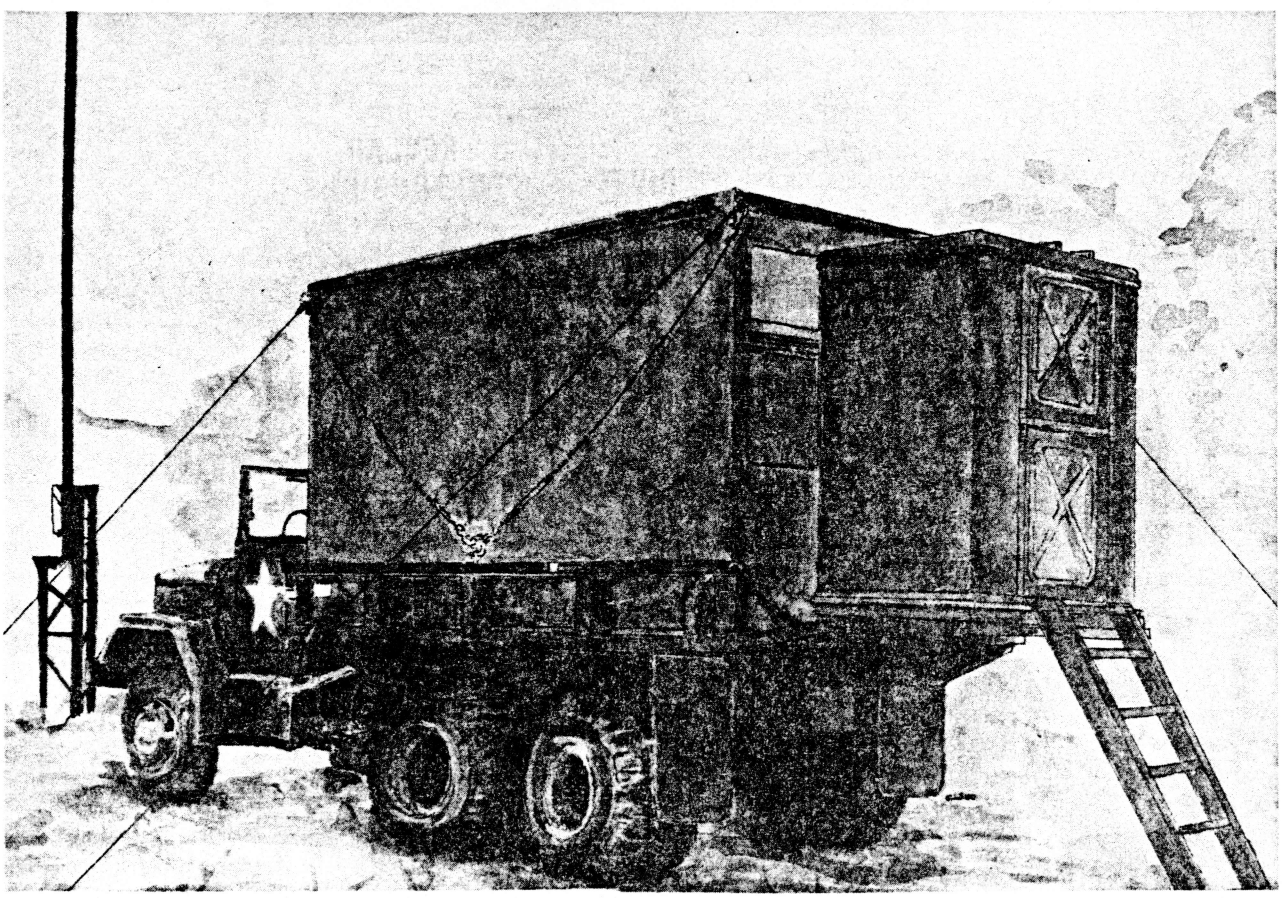


Figure 2. Model T HATS.

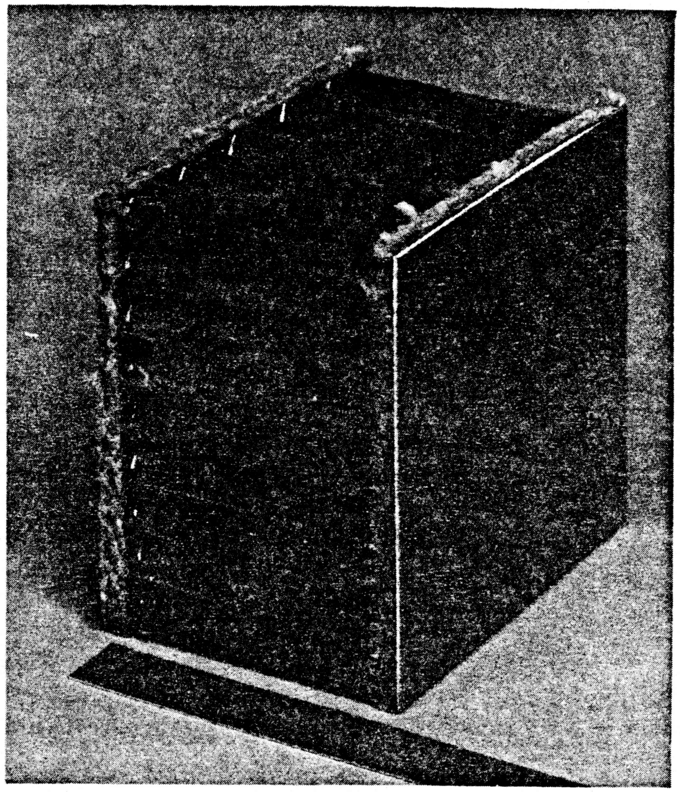


Figure 3. Model T wall panel.

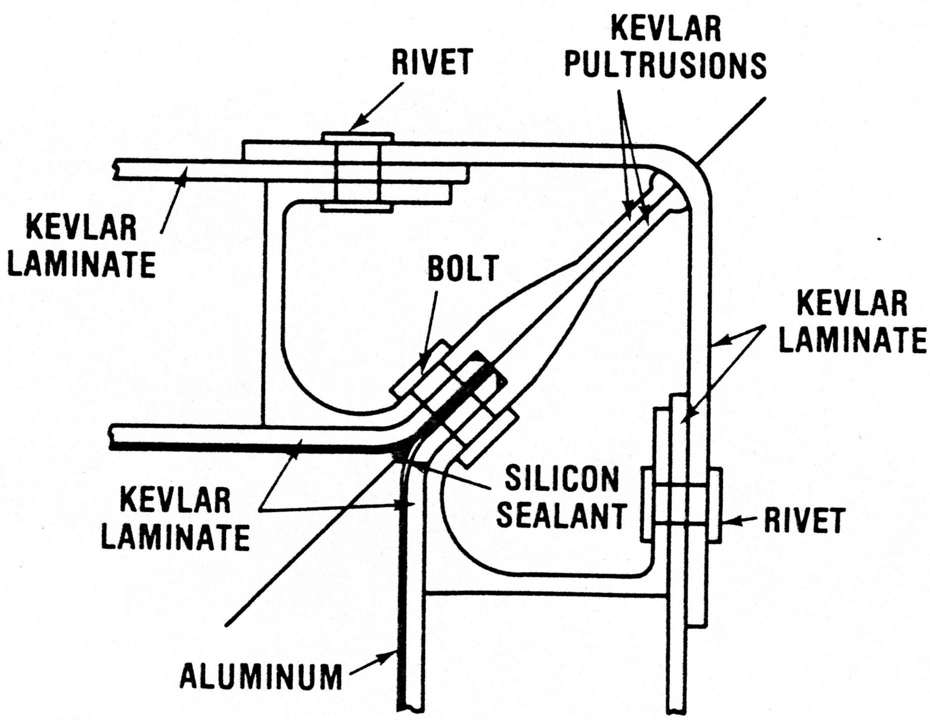


Figure 4. Model T panel edge assembly.

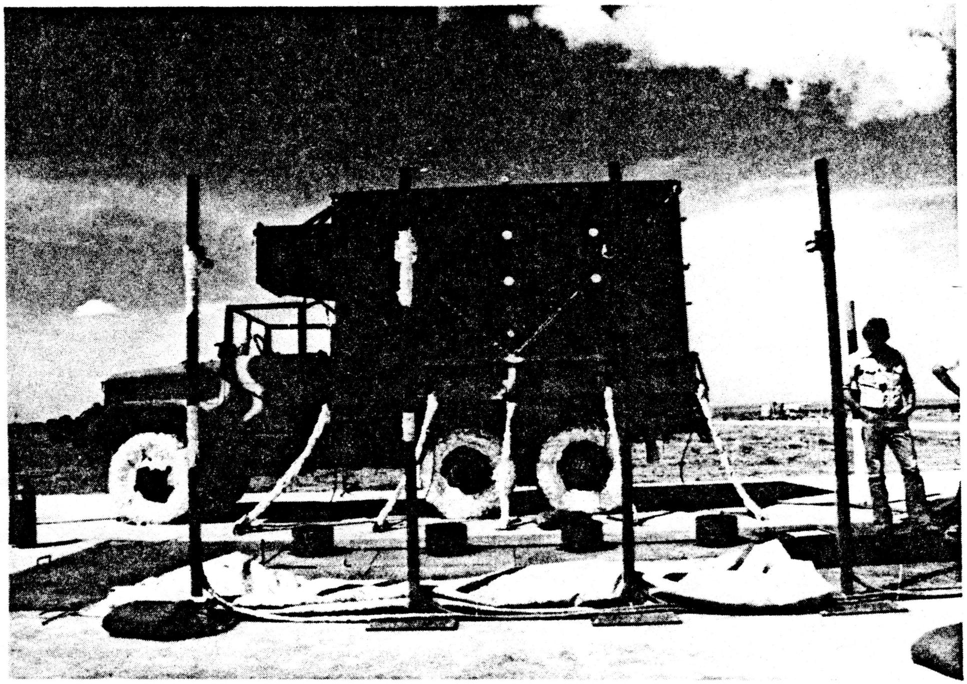


Figure 5. MILL RACE test: shelter before test at 6.0 psi and 40 cal/cm^2.

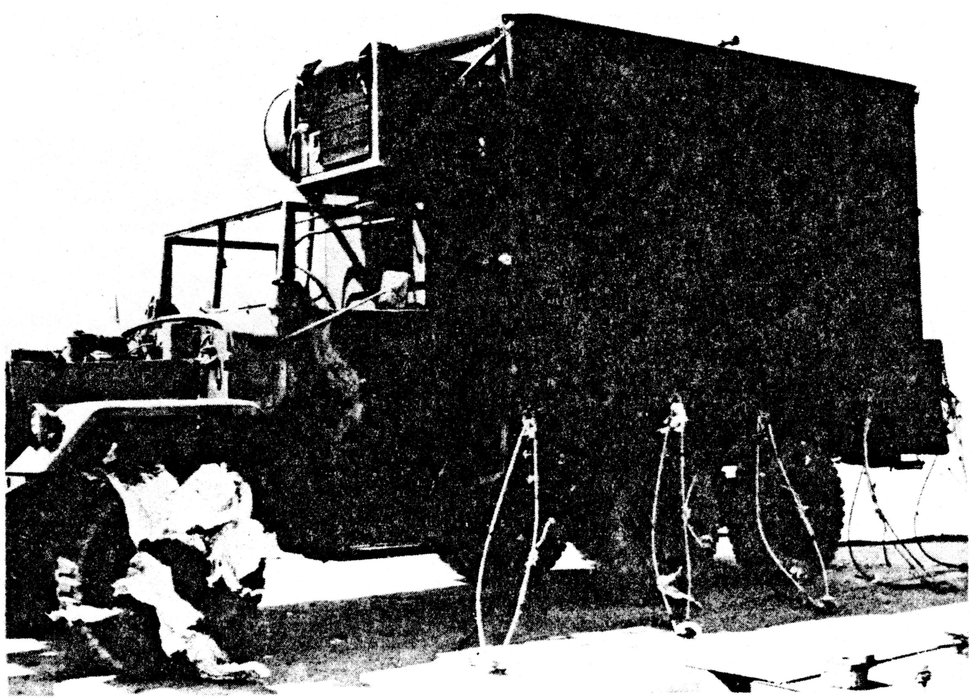


Figure 6. MILL RACE test: shelter after test at 6.0 psi and 40 cal/cm^2.

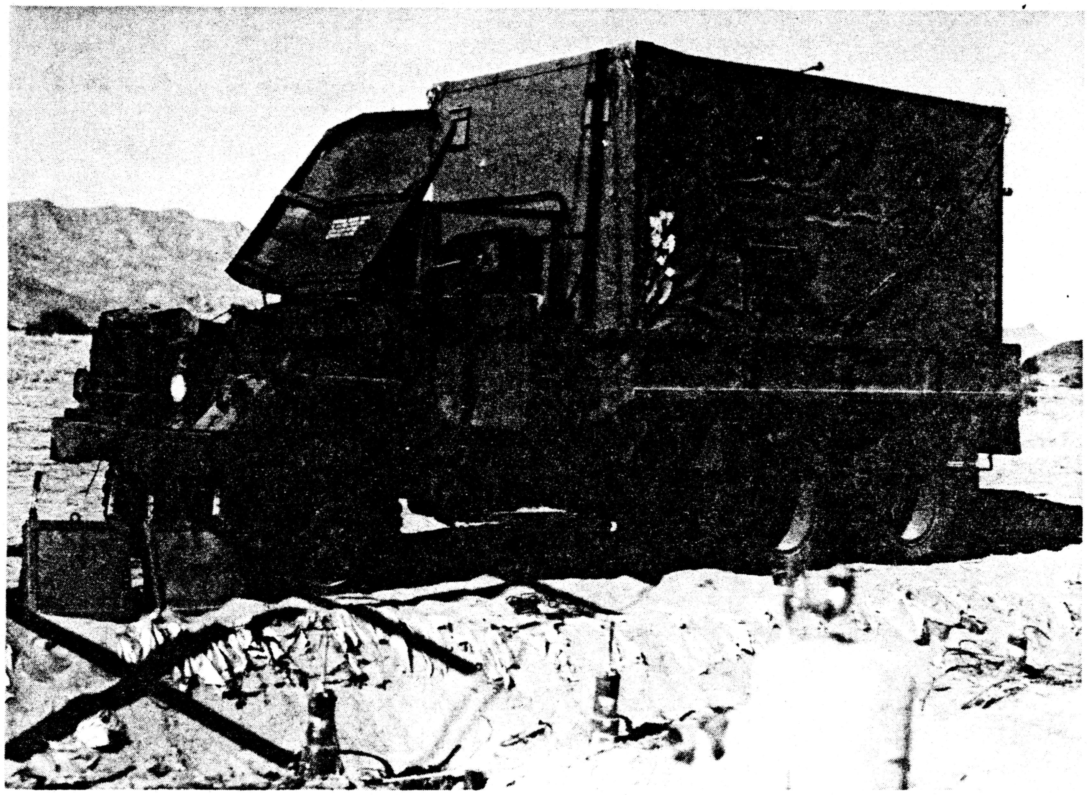


Figure 7. Standard shelter damage, 4.5 psi and 40 cal/cm^2.

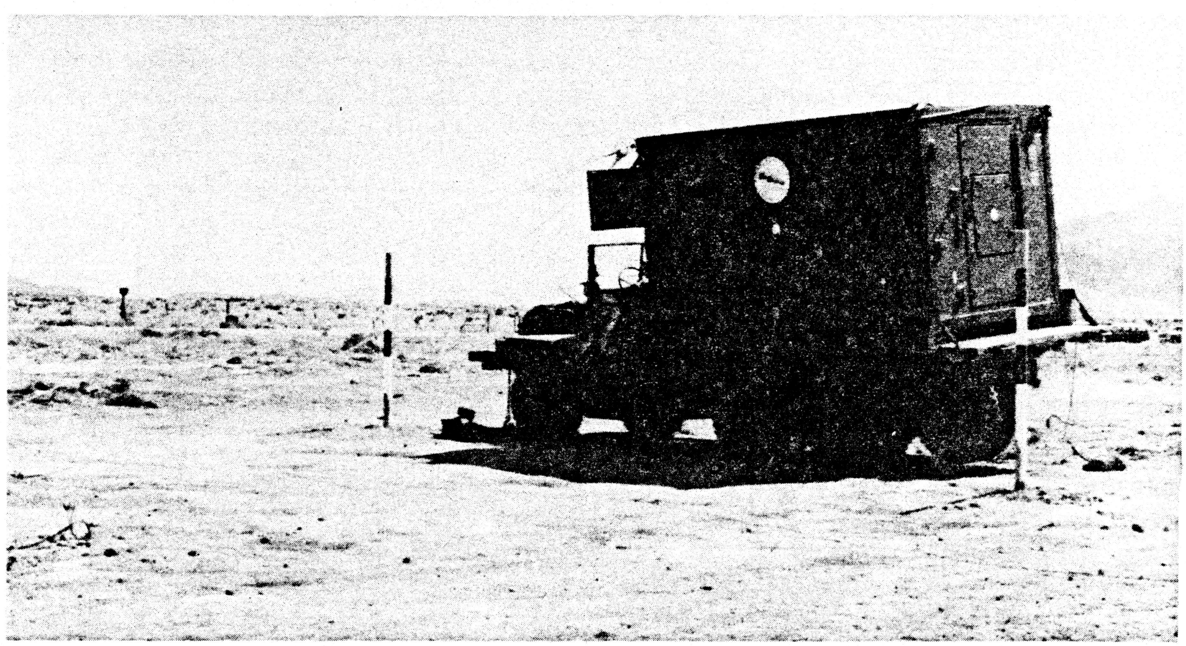


Figure 8. MILL RACE test: after test at 90 psi.

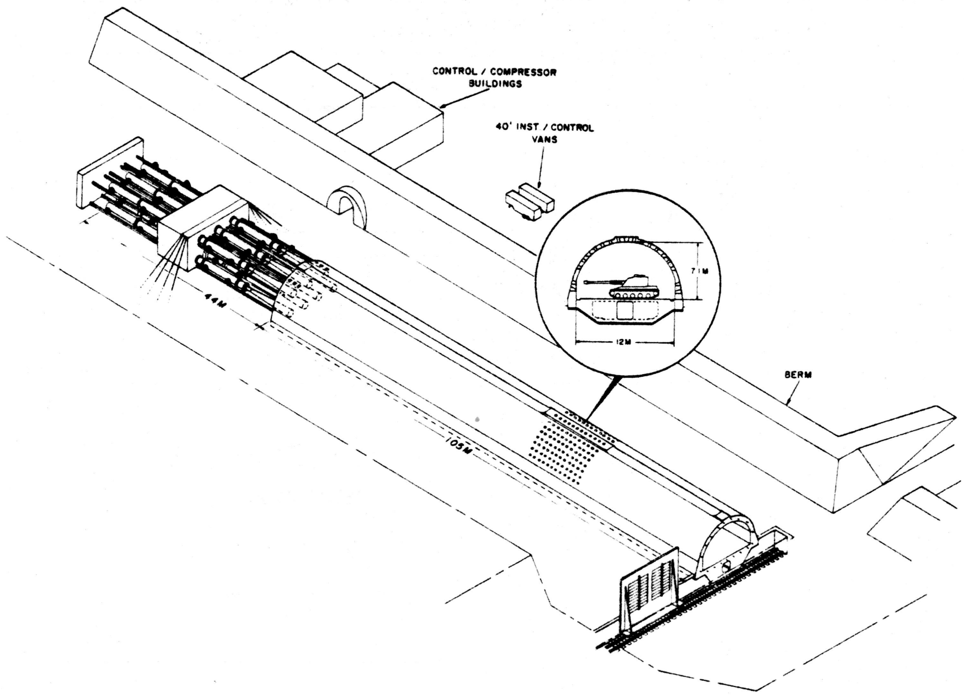


Figure 9. French Large Blast Shock Tube at Gramat, France.

Physical Security Standard for Defense Communications Systems. HDL has derived the threat and a draft military standard for the physical security of DCS sites for DCA (through the Defense Communication Engineering Center). This work was based on an earlier HDL study of the vulnerability of manned and unmanned microwave radio relay sites to damage that can be inflicted by vandals and saboteurs.

The new threat document is based on intelligence of all known adversaries including vandals, saboteurs, and terrorists. It is tailored to the prehostility scenario and details sizes of forces, skills, and weapons/tools available.

Survey questionnaires were sent out to 700 DCS sites to establish the range of physical security problems existing. The results of the questionnaires were used to define security measures that are required for special (unique) sites in which the security measures for typical sites would not be adequate. The draft military standard has two major sections, one for typical sites and one for unique sites.

The concept of zones, or defense in depth, was used in the standard. The zones of a typical site are shown in figure 10. For physical security, the outer zones are for instrusion detection. Working inward, each zone barrier is more difficult to surmount, so that the penetration of these barriers shows increasingly serious intent on the part of the intruder. At least two different intrusion alarms are placed in the outer zones to provide a redundant intrusion alarm for a response force. The interior zones provide delay, allowing the response force time to travel to the site before the adversaries can inflict damage. A total of 31 design practices are included in the standard using the unit page standard format for each.

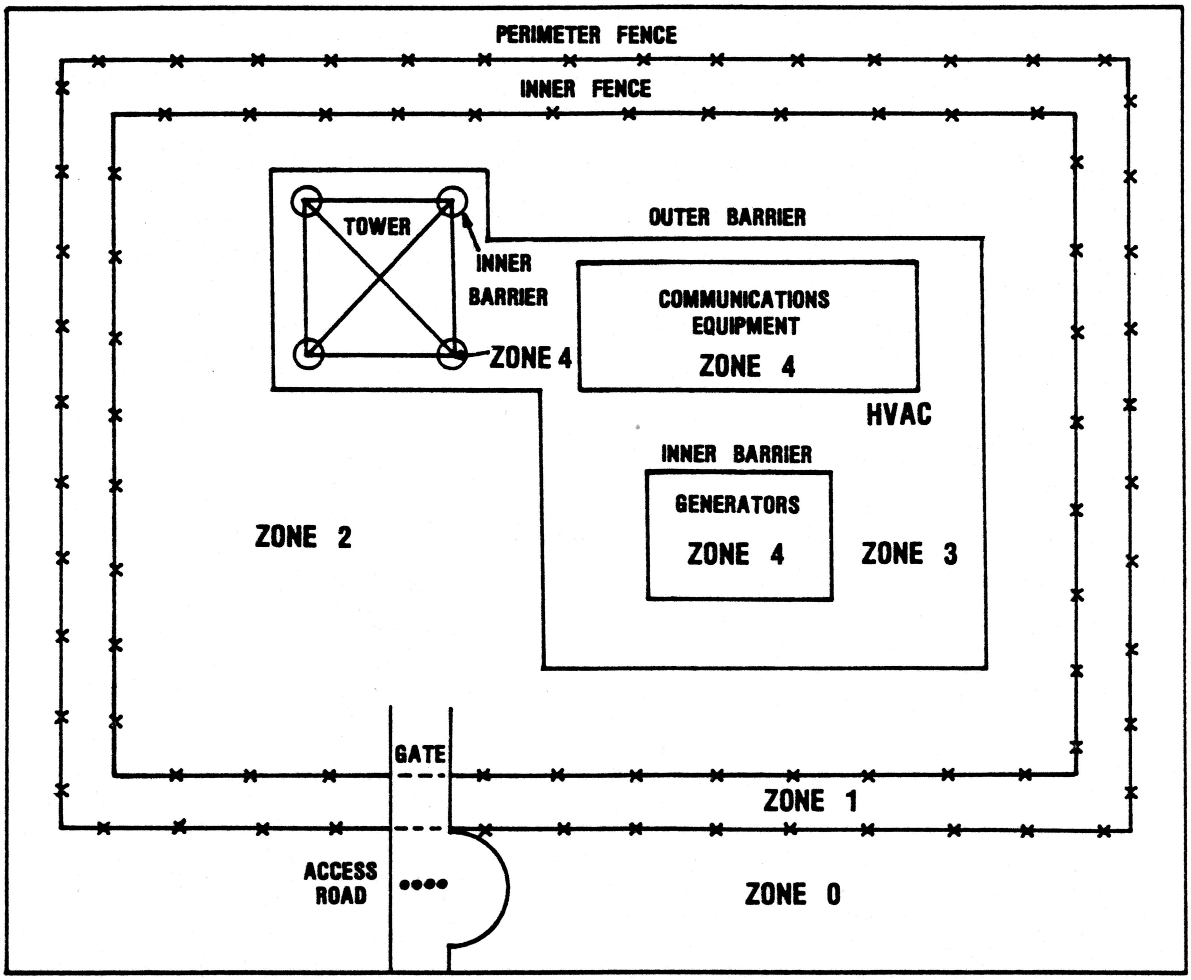


Figure 10. Example of security zones for a generic unmanned DCS site.

Nuclear Effects Support Team. The Nuclear Effects Support Team (NEST) was formed to provide NWE expertise to developers of nuclear-survivable Army materiel. The team is located at HDL and consists of experts from HDL and BRL in all NWE areas including EMP, blast, thermal radiation, and initial radiation. The team provides developers (PM's and contractors) with technical and managerial advice and assists in all phases of systems development. Typically, NEST assists in the formulation of requests for proposals and reviews nuclear survivability program plans, hardening design guidelines, engineering change proposals, and written Statements of Work. Also, in FY 81, NEST has provided members to several Source Selection Boards, including those for the Multiple-Launch Rocket System, the Single Subscriber Terminal, the Division Air-Defense Gun System, Military Computer Family, Direct Support Automatic Test Support System, and Modular Traffic Communication Center.

All the DARCOM R&D commands are represented in the list of developers that NEST is currently assisting. The great emphasis that the Army places on producing nuclear-survivable systems is reflected in the increase in the number of projects being assisted by NEST (26 projects in FY 79, 45 projects in FY 80, 81 projects in FY 81). A representative sample of some of the systems receiving support from NEST follows.

- Global Positioning Satellite System (GPS)
- Division Air-Defense Gun System (DIVADS)
- Firefinder
- Multiple-Launch Rocket System (MLRS)
- Military Computer Family (MCF)
- Remotely Piloted Vehicle (RPV)
- Multi-Service Communications System (MSCS)
- Fire Support Team Vehicle (FIST-V)
- Sigma
- Direct Support Automatic Test Support System (DS-ATSS)
- Modular Traffic Communication Center (MTCC)
- Steerable Null Antenna Processor (SNAP-1)

Nuclear Weapons Effects Technology Development/Application

A key element in the NWE program is the development of the tools and technology to perform the vulnerability assessment and hardening of systems. Equally important is the determination of the NWE sensitivity of new system designs and fabrication techniques to assure that nuclear Achilles' heels are not inadvertently built into systems in the pursuit of cost-effectiveness. In addition, every effort is made to apply or transfer gains achieved in weapons effects to other areas.

EMP Environment Research. Three major tasks were advanced in the last year: (1) coordinating and editing the Army Low-altitude Air Defense System (LoADS) EMP Environment and Coupling Handbook, (2) consolidating state-of-the-art HEMP prediction technology into one easily used computer code, and (3) developing and distilling a data base of tactical burst EMP environment predictions to assist specification of EMP survivability criteria.

Under the sponsorship of DNA and BMDSC, HDL coordinated and edited technical input from a number of contractors and government laboratories to devise an EMP Environment and Coupling Handbook for the preprototype LoADS antiballistic missile system for defense of MX and Minuteman. HDL also made technical contributions to the handbook and, using the NEMP near-surface burst EMP code, participated in developing EMP environment descriptions used to derive LoADS EMP survivability criteria.

HEMP prediction technology was successfully consolidated into one flexible computer code, designated ROUND-1. The code incorporates previous one-dimensional approximations to Maxwell's equations for the high-altitude burst regime, including the high-frequency, far-plane, and congruent ray approximations. The code uses state-of-the-art early-time calculational methods, including nonequilibrium conduction electron temperature, electromagnetic self-consistency, conduction electron formative time lag, obliquity factor treatment of Compton electon scattering, and angular distribution of Compton scatterers. Late-time calculational features include analytic gamma second scatterers and Monte Carlo treatment of additional gamma scatterers. Current work is directed toward incorporating the conducting earth by means of an image system solution. The computer code will be applied to the problem of defining late-time HEMP and refining early-time HEMP survivability criteria.

EMP data have been extracted from the HDL tactical EMP library of NEMP code results for many observer positions. Preliminary analysis has been completed to distill the data into compact form. Further analysis will permit construction of a worst-case tactical EMP, which will assist in defining tactical EMP survivability criteria and development of a tactical EMP simulator.

EMP Coupling Technology. During FY 81, an extensive coupling analysis was performed for the Pershing II missile platoon. Data collected at HDL's scale-model facility were used to validate a transmission line network (TLN) representation of the coupling to the external cables. This validation was performed for several system orientation angles to fully investigate the analytical accuracy. The TLN can also calculate the signals coupled

through the cable shields. A parametric study of the internal signals will be performed in FY 82 to determine the worst-case waveforms for the system electronics.

In addition, a study was made of the importance of the frequency dependence of soil properties in calculating plane wave reflection coefficients. Soil conductivity, σ, and permittivity, ε, vary greatly over the frequency range of interest for EMP. However, it was found that these variations only produce slight deviations from the reflection coefficients calculated with constant parameters. Multiple reflections from a stratified earth were also considered.

EMP Hardening Technology. Radio-wire integration (RWI) equipment provides the field commander with the capability to interconnect tactical radios and telephone networks. Field wires, 400 m to 32 km long, are used to interconnect these networks and are frequently terminated at the interface of signal-entry panels using standard binding-post connectors. Often when EMP and lightning protection is required, surge arresters (spark gaps) will be applied between the signal lead of the binding-post connector and ground, usually through several feet of wiring harness. However, this circuit arrangement reduces the effectiveness of conventional spark gaps, which, in addition, are inherently limited by a large impulse breakdown voltage. The problem is magnified by the spark gap's lead inductance. To compensate for this circuit response, secondary protective components are generally cascaded with the spark gap; however, component selection depends on the ability of the spark gap to efficiently suppress EMP and lightning transients.

Generally, TPD's that are developed for field-wire binding-post inputs are add-on devices. Recently, however, a surge arrester has been developed that integrates the binding-post connector into a TPD. Designated a BPSA (binding-post surge arrester), this TPD will reduce the problem arising from conventional arrester circuitry: excessive impulse breakdown voltage. In addition, the BPSA will also suppress the transient signals at the interface—a significant TPD characteristic.

Replacing binding-post connectors with BPSA's is an effective method for protecting equipment that uses these connectors as inputs for signal wires. The BPSA is basically a feed-through assembly, as are all binding-post connectors, but it is also a self-contained coaxial gas tube with zero lead inductance; consequently, the effectiveness of this surge arrester is enhanced and secondary protective components may not be necessary.

Single-Channel Radio Surge Arresters. A value-engineered miniature coaxial voltage clamp (CVCM) was thoroughly evaluated and found to exceed all design requirements. At the request of the Communications-Electronics Command (CECOM), the CVCM was incorporated into a low-profile right-angle connector with no increment in production cost and no loss of performance.

A simple locking ring was invented which makes the CVCM tamper-proof for an added cost of about 7 cents each. The ring alone has great potential for other anti-tamper or high-vibration applications.

Another single-channel radio surge arrester was certified during tests at Tobyhanna Army Depot. This is another in the continuing series of highly successful cooperative efforts conducted with the support of depot personnel.

Device Damage Testing. The study of intervendor variations of the pulse hardness of discrete semiconductor devices, previously reported, was extended and a final report on this work was prepared. A study is continuing of how the simultaneous pulsing of the emitter-base and collector-base junction of a transistor affects the failure levels determined for each junction separately.

Tactical Environment System Validation Development. This program is an extension of the Tactical Environment Multiple Systems Evaluation Program (TEMSEP) which ended in FY 80. The primary objectives of TEMSEP were to develop, verify experimentally, and apply analytical methods to assess the vulnerability of Army systems to tactical endoatmospheric nuclear threats. The objective of the current program is to develop a general method for validating the hardness of Army systems to tactical endoatmospheric environments. During FY 81, an algorithm was

developed which can be applied to most systems. The absence of a suitable simulator complicates the validation effort greatly, and therefore several tests are required with supporting analysis. In FY 82 an existing Army system will be analyzed and specific validation tests will be planned, with the actual testing to occur in FY 83.

Source-Region EMP Coupling and Simulation Research. The AURORA Flash X-Ray Facility is a potent simulator for transient gamma radiation, but because of its structure and the temporal behavior of the radiation output, the resulting EMP in the exposure room differs significantly from that expected from an endoatmospheric nuclear detonation observed at the same conductivity levels. Past simulation efforts concentrated on enhancing the electromagnetic fields inside the AURORA test cell with a large transmission line. Several antennas were tested with this transmission line in AURORA, and the data were used to validate coupling tools. During FY 81 the simulation and coupling efforts were focused on long lines and the deep source-region environment.

In particular, considerable progress was made toward the achievement of two objectives:

- The first objective was the development of a small transmission line for exciting slow-wave structures in conjunction with AURORA. These slow-wave structures are designed to model long wires or cables in a source-region EMP environment. These cable studies will result in the development of a current-injection system for use in system validation testing.

- The second objective was the extension of existing simulation techniques to include the much higher radiation dose levels relevant to deep source-region environments. The approach taken has depended on the use of AURORA in the electron-beam mode (much more efficient at ionizing the air in the test cell than the more traditional bremsstrahlung mode). Problems relating to beam stability, pulse shape enhancement, and simulation fidelity are well on the way to solution. Induced current measurements were made on various cylinders, and good comparisons were achieved with calculated responses. Efforts will continue in FY 82 to refine the environment produced in the electron-beam mode for source-region simulation.

Test Set for Surge Arresters. In a joint effort involving HDL, CECOM, and a contractor, the TS-3760/U is being production engineered, documented, and produced at HDL. The significant hurdles of militarizing (according to MIL-T-28800B) a highly sophisticated electronic item have been overcome. Production will begin in the second quarter of FY 82.

Achievements in SGEMP Studies. An extensive study of the tactical nuclear European battlefield this year revealed that a large number of command and control systems in forward areas are exposed to a strong system-generated electromagnetic pulse (SGEMP) threat environment, even as they survive the other more familiar nuclear battlefield threats (tissue dose, blast, and thermal illumination). The study combined current estimates of Soviet weapons capability and attack philosophies with realistic deployments of U.S. Army command and control systems inside the divisional sector. The effects of various nuclear weapon laydowns were estimated using accepted radiation-transport algorithms and Monte Carlo calculations. More detailed studies of the radiation/system interaction have been carried out on selected systems. The results of the battlefield survey and the interaction calculations have provided a quantitative measure of the SGEMP threat to be expected on the nuclear battlefield; these results again demonstrated the importance of the use of interior electromagnetic shielding and protection techniques for the nuclear survivability of systems.

Hardness Assurance and Maintenance. HDL plays an active role in the development and review of test procedures, guideline documents, standards, and data item descriptions which support the development, production, and maintenance of nuclear-survivable equipment. These activities take place in two groups: a DNA-sponsored, joint government-industry working group, and a Joint Logistics Commanders' Panel on Logistic Support of Nuclear Hardened Systems.

Radiation Effects on Large-Scale Integrated (LSI) Circuits. Measuring radiation-induced degradation of LSI circuits presents a special challenge because of the complexity of these circuits. Testing them thoroughly is a difficult job, but the increasing use of microcomputers in modern Army materiel makes this job a necessity.

We can now measure radiation effects on many different microcomputer components. This year, HDL evaluated a microprocessor (8085) and several peripherals associated with it: 8279 keyboard-display driver, 9551 serial input/output (I/O) port, 9555 parallel eight-bit I/O port, and an 8155 combination random access memory (RAM), parallel port, and programmable timer. Virtually all the preparatory work has been done for tests of the 8086 16-bit microprocessor and the 4116 16k RAM. Whenever possible, samples from several manufacturers are tested because of known manufacturer-to-manufacturer variations in response. Two reports on this work were issued[2,3] and much of the data directly used by Army system development contractors through the NEST.

Tactical System Radiation Vulnerability and Hardening. HDL is taking the lead in assuring that fielded Army equipment will survive tactical nuclear warfare. Using guidance from TRADOC for priorities, the survivability of many different systems and assemblages has been analyzed. These analyses are followed up with confirming experiments where required. Hardening fixes are recommended for "soft" equipment.

The following systems were analyzed this year:

- AN/TPQ-37 Missile Minder
- AN/GSG-10 TACFIRE
- AN/MPQ-49 Forward Area Alerting Radar (FAAR)
- MD-522 Modem

The impact of new, higher survivability criteria and low operating temperature on the analyses of the past several years was determined.

Confirming experiments were done on the AN/GRC-103 radio, the AN/TD-660 multiplexer, the AN/TD-754 multiplexer, and the universal standard voltage regulator used in mobile electric power (MEP) units. Several Army MEP units are being analyzed.

Fuzing Alternatives for 155-mm Nuclear Projectile. Techniques of electronic warfare pose potential problems to electronic systems on the modern battlefield. As a particular example of current concern, a study was performed on the efficacy of using a timer backup to the XM749 proximity fuze for the 155-mm nuclear projectile in order to increase the round's effectiveness when facing a jamming threat. This postulated backup timer "enables" the fuze at some time before the proximity fuze height-of-burst setting and fires the round if sufficient jamming is detected.

Effectiveness was measured in terms of expected target coverage, which is computed by means of a Monte Carlo simulation incorporating target location error; range, deflection, and height errors for the proximity function; and correlated range and height biases for the timer backoff time setting. An area target was assumed, consisting of personnel in tanks uniformly distributed over a circular area: damage was computed by means of a damage radius "cookie cutter." Both short- and long-range projectile trajectories were considered, and the effects of using meteorological data for firing and/or time registration were examined. The methodology developed was general and can readily be adapted to other fuzed rounds.

Results were obtained assessing the effectiveness of the timer backup in low-power jamming, high-power jamming, and benign (no jamming) environments. The importance of the fuze sensor threshold was investigated and estimates obtained for the proximity fuze dud rate in the postulated jamming environment. Also, a comparison was made between the proximity fuze and a selectable timer for the 155-mm nuclear projectile in a benign environment.

Achievements in Fiber-Optic Link Design. The fiber-optics state of the art has been advanced with the completion of a prototype radiation-hardened analog fiber-optic data link. Developed for DNA's Nuclear Weapons Effects Test Program, the link is designed to carry radiation-response signals from a test object electrically isolated in a cold evacuated

[2] *Neil D. Wilkin, Ionizing Radiation Susceptibility of Microprocessors, Harry Diamond Laboratories, HDL-TR-1949 (1981).*

[3] *Charles T. Self, Ionizing Radiation Effects on Four Random Access Memories, Harry Diamond Laboratories, HDL-TM-81-12 (1981).*

radiation tank to a distant recording station. The link can be controlled from the receiver end, either by computer or by manual operation.

The transmitter carries several remote-control features: a switchable four-channel input (including universally matched balun transformers), a calibration waveform generator, a variable attenuator, an on/standby status control, and automatic battery recharge and transmitter heater systems. The transmitter also incorporates a unique modal noise suppressor that was developed and patented for the government. It relies on a high-frequency laser modulation outside the link passband to decrease the laser coherence and the attendant interference-effect noise. Because the transmitter may be inaccessible for long test periods, it has been designed to draw very little current from its batteries: 200 μA on standby and 100 mA when the laser is transmitting data. These features are embodied in a miniaturized transmitter measuring only 3-1/2 by 3-1/2 by 6 in. (9 by 9 by 15 cm).

The completed prototype provides a 15-kHz to 350-MHz bandwidth and at least 35 dB of dynamic range and harmonic suppression across its operating band. More recent bench tests of the link have been performed to evaluate a newly marketed Telefunken photodiode; the link's upper bandwidth limit was shown to be increased to 750 MHz. The functional versatility and electrical performance of this prototype is unmatched in any other fiber-optic link on the commercial market or in the government inventory.

NWE Simulation

Since at this time tests cannot be conducted in a real nuclear weapon environment, simulators are the only available link to reality. The goal of this element in the NWE program is to operate and develop the most realistic simulators for effects research and system testing.

In support of HDL's position as the Army's Lead Laboratory for Nuclear Weapons Effects, NWE simulation efforts continued to include the development and operation of equipment for performing EMP tests on a variety of DoD systems.

EMP Simulators

High-Level Simulator. The Army EMP Simulator Operation (AESOP) is located at the HDL Woodbridge Research Facility. AESOP can produce 50 kV/m, free field, at 50 m on its centerline. AESOP has continued to support the Army and a variety of DoD customer test programs throughout FY 81. This facility is available to DoD contractors and other government agencies.

During FY 81, AESOP supported such high-priority DoD EMP test programs as the DNA effort to provide a pulse and continuous wave (cw) data base for use in comparing cw and pulse response of a fixed test object. Other significant tests supported by AESOP included the M74 antipersonnel and M75 antitank mines and Stinger and Hellfire missiles.

Low-Level Simulators. Included in HDL's family of low-level simulators at Woodbridge are (1) the Repetitive Electromagnetic Pulse Simulator (REPS), (2) a low-level Repetitive Pulse Generator (RPG) used in the AESOP antenna structure, (3) the Vertical Electromagnetic Pulse Simulator (VEMPS), and (4) a quarter-megavolt RPG. These simulators offer an economical approach to obtaining EMP signature data on various kinds of equipment. Their repetitive capabilities ensure maximum data gathering at minimum cost.

Repetitive Electromagnetic Pulse Simulator (REPS). REPS was originally developed as a self-contained transportable simulator to determine the EMP susceptibility of such facilities as the Stanley R. Michelson SAFEGUARD Complex, Grand Forks, ND, and the SAFEGUARD Missile Site Radar Power Plant. During FY 81, REPS has been operated exclusively at the Woodbridge facility, and it is planned to remain there to support future Army and DoD programs.

This megavolt repetitive simulator can provide an EMP free-field environment of 6 kV/m at 5 m on the pulser centerline. This system radiates a threat-related waveform with a rise time of less than 10 ns and pulse duration of approximately 800 ns.

During FY 81, REPS was used extensively in support of the GVF test program, including the

Satellite Terminal EMP Protection (STEP) tests, and for testing the XM2/3 Infantry/Cavalry Fighting Vehicle (IFV/CFV).

Vertical Electromagnetic Pulse Simulator (VEMPS). VEMPS provides the Army EMP test programs with the capability of testing equipment at high-frequency and fast-rising EMP in a primary vertical field environment. VEMPS can radiate an electromagnetic free field up to 2 kV/m at 50 m from the antenna. The rise time of this simulator is less than 10 ns, and the pulse duration is approximately 100 ns. VEMPS was used extensively during FY 81 in conjunction with the GVF test program.

Tests involving the above simulators have been considerably improved by the continual updating of the automated System for Monitoring and Recording Transients (SMART) and the Data Analysis and Processing System (DAPS). These improvements have been responsible for significant increases in the quantity and quality of data during FY 81.

EMP Simulator Support Facility. The High-Voltage Simulation Facility was used extensively in FY 81 to provide a controlled environment for various direct-current-injection tests, and in support of refurbishment of the REPS generator.

Transient High-Voltage Source. A high-voltage, high-energy portable Marx generator, designed and built by Physics International Co., was procured by HDL. This 400-kV generator, with a source impedance of less than 10 ohms, can deliver 22 kJ. It can produce a several-thousand-ampere pulse with a risetime of about 100 ns and a fall time of a few microseconds. The entire pulser and control equipment is mounted on a trailer and can be manually triggered or synchronously triggered with other simulators, thus making it a versatile tool for EMP hardness verification and current-injection testing, as well as for fundamental research. It has been used in successful tests of the TTC-39 switch. The current-injection testing techniques used in the TTC-39 program will be further developed into a methodology that will complement the use of existing EMP simulators when a distributed system is being tested.

Electromagnetic Scale-Modeling Facility. During FY 81, the electromagnetic scale-modeling facility was used to initiate coupling studies for the Pershing II modeling effort. An extensive study was begun to model various satellite terminal sites for the STEP program. This program was sponsored by the Army Communications Command (ACC). A new linearly polarized antenna was built to provide a properly scaled pulse for 25:1 models. A large turntable was built to allow extensive models to be rotated without removing them from the sand. A continuing effort has been under way to update programs written for the minicomputer-controlled digital-processing oscilloscope system to improve the efficiency of data acquisition and analysis.

Continuous Wave Test Facility. The Continuous Wave Test Facility is an outdoor measurement system for determining the interaction and coupling characteristic of antenna systems in the presence of a finite conducting ground. It consists of a set of antennas that can radiate broadband vertically or horizontally polarized fields over a 100-by 200-m test area, along with an automated data-acquisition system to measure the response of the test antenna relative to the incident field. The frequency range (2 to 500 MHz) of the transmit and receive systems spans the major portion of the EMP spectrum; hence, the facility is used to study EMP-related interaction and coupling problems. This is accomplished by making the appropriate measurements required to represent the antenna system by a Thevenin or Norton equivalent circuit for a specified EMP. The data are recorded in digital form on cassette magnetic tapes and are then transferred via telephone lines to HDL's IBM 370/168 computer for subsequent data analysis.

An effort to upgrade the facility was initiated late in FY 80. During FY 81, an rf-shielded van was refurbished and all the cw facility electronics were installed in this van. With this development, the facility can be deployed at a remote site and operated over a limited frequency range (30 to 100 MHz). During the present fiscal year, the antennas and their supports will be redesigned for easy installation and removal.

Radiation Simulators

AURORA. The AURORA facility continued to be very active, serving a mix of strategic systems contractors, government laboratories, and in-house research programs. Survivability/vulnerability proof tests of MX subsystems and other strategic systems were conducted by Bendix, Rockwell International, Northrop Corporation, and RCA. All these tests used the AURORA simulator in its traditional bremsstrahlung-producing mode.

In-house experiments included simulator-upgrading studies,[4] characterization of the bremsstrahlung output,[5] and studies to characterize the operation of AURORA in negative polarity. These latter experiments used a reversed bremsstrahlung diode with a graphite anode for a load for one of the four arms of AURORA. Successful operation to 105-kV Marx-generator charging voltage was demonstrated. This mode of operation is expected to be important for future ion-acceleration studies.

The joint NRL/HDL light-ion beam research program[6] was continued this year with a major modification of the AURORA simulator. The goal of this program, which is supported by DNA, is to develop intense light-ion beams as drivers for the thermonuclear pellets in inertial confinement-fusion (ICF) applications. This new series of experiments uses a new ion diode which is mounted not on the end of the AURORA vacuum coaxial transmission lines, but very near the oil-vacuum-interface insulator stack. This mode of operation required extensive modifications to the facility including removal of the vacuum coaxial lines, and installation of new supporting structures and an inductive isolator in the simulator. The machine is operated in the positive-polarity mode for these experiments. Results are still being evaluated.

The biggest single program at AURORA this year was a source-region EMP simulation research program sponsored by DNA. A major advance achieved this year was the extraction of an 8-MeV, 200-kA electron beam from one of the AURORA vacuum coaxial lines and propagation of this beam through the 20-m length of the AURORA test cell at atmospheric pressure without instabilities.[7-9] Following this initial success, a number of other experiments were done to understand and characterize the behavior of such beams. These included variations of beam diameter, window material and thickness, and anode-cathode geometry. The ultimate goal of this research is to extract four electron beams simultaneously, thus using the entire output of AURORA to produce time-varying air conductivity over a very large volume in order to simulate certain aspects of the source-region EMP environment.

Pulsed Power Development. A new concept of pulsed power generation has been investigated which would be less expensive, would permit single-pulse, burst, and repetitive-pulse operation, and would be considerably smaller, lighter, and more flexible than systems based on current technology. This concept, called Camelot,[10] incorporates several novel concepts which must be investigated experimentally before a prototype system can be designed. One of these, the fluid dielectric diode, was investigated experimentally this year. Approximately 400 shots were fired on the FX-45 pulser (HIFX) into a vacuum load through a transmission line filled with Dow-Corning type 704 diffusion pump oil. Thus far, the data suggest that one can sustain fields of 215 kV/cm for about 20 ns across the oil/vacuum surface with only about a 10-percent probability for flashover. The large-area, long-time-breakdown studies relevant to the intermediate storage of energy in the torus has been proposed to be undertaken by the Sandia National Laboratory.

---

[4] *A. G. Stewart, Upgrading the AURORA Simulator, Harry Diamond Laboratories, HDL-TM-80-28 (October 1980).*

[5] *K. G. Kerris, The AURORA Bremsstrahlung Environment, Harry Diamond Laboratories, HDL-TM-81-18 (July 1981).*

[6] *R. A. Meger et al, High Impedance Ion-Diode Experiment on the AURORA Pulser, J. Appl. Phys.* **52** *(10) (October 1981), 6084-6093.*

[7] *M. S. Bushell et al, The Direct Injection of Electrons into the Air—An SREMP Simulation Tool, 3rd International Pulsed Power Conference (June 1981).*

[8] *K. G. Kerris et al, AURORA—A Versatile, Multi-Mission Simulation Facility, 1981 Nuclear and Space Radiation Effects Conference (July 1981).*

[9] *K. G. Kerris et al, Diagnosis and Characterization of Large-Area Electron Beam, 23rd Annual Meeting, Division of Plasma Physics, American Physical Society (October 1981).*

[10] *A. G. Stewart, Camelot—A Novel Concept for a Multiterawatt Pulse Power Generator, Harry Diamond Laboratories, HDL-SR-81-1 (April 1981).*

High-Intensity Flash X-Ray (HIFX) and Cobalt-60 Facilities. The HIFX and cobalt-60 facilities have continued to be used principally by Army experimenters during this year. However, government contractors have expressed increasing interest in these facilities. Reasons for this are the versatility and flexibility of the radiation sources, data-acquisition systems specifically suited to radiation effects testing, and some unique capabilities, such as the high-exposure-rate air-source capability of the cobalt-60 facility.

Army-sponsored experiments at both facilities have been primarily in the area of fiber optics, microprocessor systems, and MOS devices. Non-HDL users have included Mission Research Corp. with a DNA-sponsored gas-ionization study, Rockwell-Collins with a microprocessor test, and Sperry-Univac with a fiber-optics test. The utilization rate of both facilities was about 40 percent, with no significant down time for emergency repairs or maintenance.

Tactical Nuclear Studies

The NWE research program emphasizes the vulnerability evaluation, testing, and hardening of individual components, equipment, and systems. By contrast, the focus of tactical nuclear studies is on evaluating the residual combat capability of selected combat elements during and after postulated nuclear scenarios and on exploring the effects of this residual capability on the outcome of possible conflicts. The sensitivity of this capability to changes in material survivability, tactics, and doctrine is also evaluated.

Fighting Unit Survivability Evaluation. Historically, the decision to harden a critical battlefield system to NWE has been based on the piecemeal selection of systems that were readily adaptable to established nuclear hardening criteria, with little rationale for hardening levels selected. To assist decisionmakers in the selection process requires a methodology with a rationale based not only on enhancing survivability but also on increasing the military effectiveness of the force. The objectives of the Fighting Unit Survivability Evaluation (FUSE) program are, first, to relate battlefield effectiveness of small tactical units to increased NWE survivability, as a function of materiel hardness level (alternative criteria) and hardening cost, and, second, to provide nuclear hardening decisionmakers with a basis upon which nuclear hardening decisions can be made with high confidence that survivability will be enhanced.

A methodology had been developed to relate battlefield effectiveness of small tactical units to the value of enhanced NWE survivability. The method can be used as a tool to identify equipment items for nuclear hardening, to perform hardening cost analyses, and to evaluate the increased survivability and unit effectiveness as a function of enhanced hardening levels. A flowchart of the methodology is shown in figure 11.

Models of each major section of figure 11 have been developed. The battlefield survivability analysis model[11] parametrically relates NWE survivability to materiel hardness. The combat capability model uses the results of the materiel hardness assessments to determine the residual capability,[12] after nuclear attack, of units using the materiel. The results of the residual combat effectiveness analysis are used as a basis for cost tradeoff analyses performed for various system hardening levels, proposed operational changes, and different levels of combat capability.

This methodology has been applied to several Army air-defense weapon systems as well as TACFIRE.[13,14] Most recently, an assessment was made of the effectiveness of a tank liner for the XM1 tank in providing radiological protection for the crew. A representative nuclear threat was used to derive several different weapon packages which were

---

[11] *K. Sweasy and J. Michalowicz, Fighting Unit Survivability Evaluation (FUSE): Effectiveness Methodology (U), Harry Diamond Laboratories, HDL-TR-1923 (February 1981). (SECRET)*

[12] *J. Klopcic, J. Kinch, and J. Jacobson, RCC: A Methodology/Code to Model Residual Combat Capability at the Unit Level, Ballistic Research Laboratory, ARBRL-TR-02156 (April 1979).*

[13] *K. Sweasy and J. Michalowicz, Fighting Unit Survivability Evaluation (FUSE): TACFIRE System Survivability Analysis (U), Harry Diamond Laboratories, HDL-TM-80-17 (December 1980). (SECRET)*

[14] *J. Maloney and T. Klopcic, Fighting Unit Survivability Evaluation (FUSE): TACFIRE System Cost-Benefit Analysis (U), Ballistic Research Laboratory, ARBRL-TR-02223 (March 1980). (CONFIDENTIAL)*

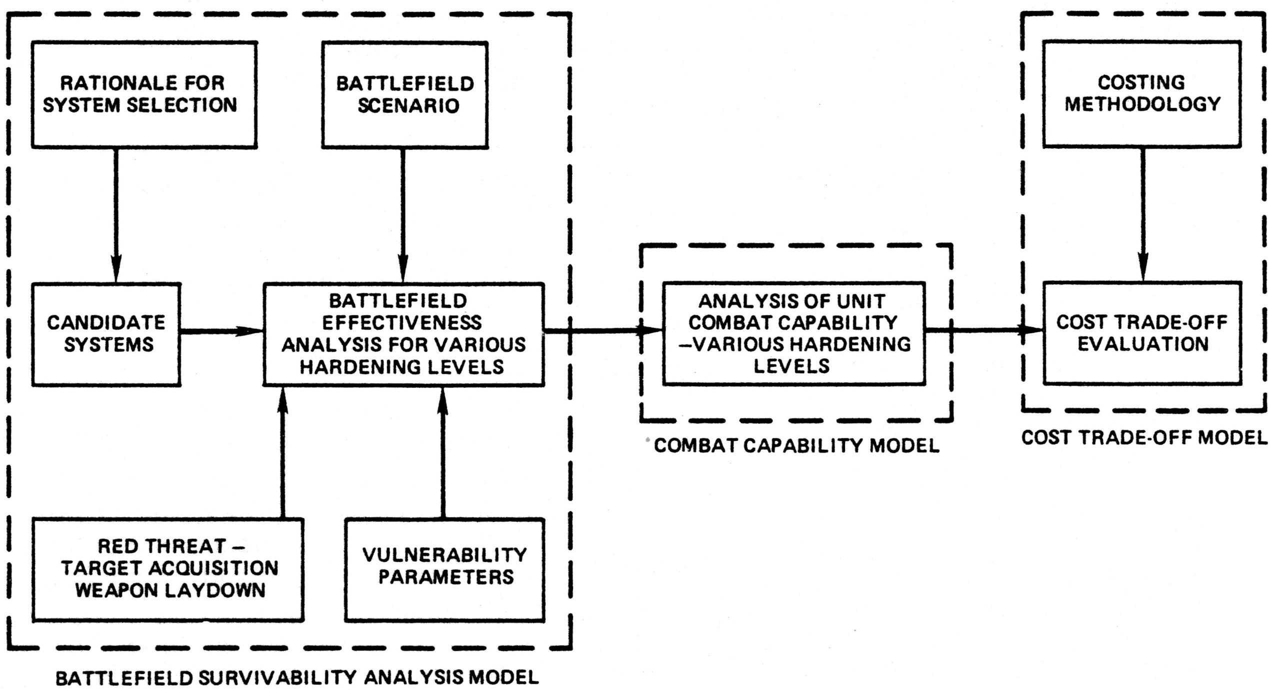


Figure 11. FUSE program flowchart.

employed by threat forces in a division-size Central European scenario. The damage was assessed after each laydown and the residual combat capability was analyzed. Hardening recommendations based upon cost trade-offs were developed.

Performance of Netted ISTA Assets in a Corps Operation. As a part of DARCOM's Army Command and Control Systems (ACCS) Systems Engineering Implementation Plan, ERADCOM was assigned the task of reviewing and developing the functional area subsystem specifications for intelligence and electronic warfare and the tasks of supporting CECOM in the fire-support functional area, specifically target acquisition. The responsibilities include optimization of the functional area as constrained by the DARCOM System Engineer, development of assigned systems and interfaces, and preparation of functional area specifications for ACCS.

The objective of the effort is to improve the specification and development of ISTA (intelligence, surveillance, and target acquisition) systems which can be successfully and optimally netted in a combined arms operation in the air/land battle.

To support ERADCOM's efforts, the CONDUCT II computer simulation model is being used; this model was developed previously for the Theater Nuclear Force Survivability C^3 Degradation (TNF/S C^3D) studies. CONDUCT II simulates corps and subordinate C^3 and intelligence functions with particular emphasis on the integration of the new generation of ISTA systems and artillery systems within the developing force structure. CONDUCT II is an event-by-event simulation model, written in GPSS-V, representing the combat and combat-support command/staff elements and communications networks for the operations and intelligence functions within a corps. Maneuver and engineer units are represented to platoon level, artillery units to battery level, and target acquisition and CEWI (combat electronics warfare and intelligence) units to sensor-team level. Major command posts and operations centers are subdivided into their primary functional areas: for example, at the main division, collection, management, and dissemination; all-source analysis center; intelligence section (G2); and operations section (G3). Communications assets include FM radio, radio-teletypewriters, external multichannel and internal telephone, and courier. The entire system is exercised by the generation of well-defined tactical missions (tasks)

that compete for command/staff decision/processing time and communications assets. These missions include (in broad categories) dissemination of orders, plans, and intelligence estimates; collection and processing of target data; intelligence and combat spot reports; and fire mission and asset tasking requests. The CEWI and field-artillery missions incorporate the use of all equipment assets critical to the performance of their missions and developed by ERADCOM.

Earlier results from the model have been reported.[15] In that analysis, Blue C^3 choke points and timelines for sensor and artillery missions, cueing missions, a nuclear refinement mission superimposed on conventional activities, and conventional first-strike duels against Red assets were determined in a dynamic C^3 environment.

Continuing analysis using the model will be undertaken to quantify the timeliness of various tactical units' workloads within and among the ISTA and artillery systems in a combined arms operation under degraded and nondegraded conditions of the air/land battle. Conclusions drawn from CONDUCT II results will then be used to identify needed improvements to the present CEWI battalion's system assets and their interoperability. Because of its unique formulation and output, it is useful in the process of selecting the preferred system development and/or product-improvement alternatives most appropriate to achieving the stated TRADOC air/land battle needs. Interoperability and subsystem performance criteria can be clearly developed and articulated into hardware development specifications using CONDUCT II as an analysis tool for this purpose.

[15] *Thomas V. Noon and Egon Marx, TNF/S C^3I/D CONDUCT: A Simulation Model of the Army's Command, Control, Communications, and Intelligence (C^3I) Process and Analysis of Conventional and Nuclear Mission Timelines (U), Harry Diamond Laboratories, HDL-SR-81-9 (December 1981). (SECRET-NOFORN)*

fluidics

Twenty-one years ago, fluidics was conceived by HDL employees, who invented the fluidic amplifier and many of the devices necessary to build fluid control systems. Fluidics is a way to build sensing and control systems with no moving mechanical parts, thus producing systems with low initial cost, high reliability, and little or no maintenance. These attractive features have thrust fluidic devices into the industrial marketplace, where fluidic shower heads, lawn sprinklers, oral irrigators, respirators, and air-conditioning controls are readily available from commercial sales outlets. Fluidics has also emerged as a viable technology in military systems where high reliability and low life-cycle costs are important.

Lead Laboratory for Fluidics Technology

HDL is DARCOM's Lead Laboratory for fluidics. In carrying out this responsibility, HDL conducts and technically manages both a 6.1 research and a 6.2 exploratory development program. The objective of these programs is to create the technology base necessary for the scientific and engineering application of fluidics so that low-cost, highly reliable fluid control systems will be available for Army needs.

The event that spearheaded fluidic development in recent years was the introduction of laminar-flow amplifiers. These quiet, high-dynamic-range components can amplify extremely small signals to a usable differential pressure output. Research on laminar amplifiers was initiated at HDL about seven years ago, and current development efforts have been enhanced by the use of low-noise sensors and gain blocks. Current development efforts, such as angular rate sensors and temperature sensors, would not have been possible without the past research on laminar components. Hence, fluidic technology as it exists today has significantly more military potential than it offered just a few short years ago.

Technology transfer of fluidics is one of the objectives of the Lead Laboratory. In this capacity, HDL staff members assist numerous government agencies with fluidic system development. In FY 81, HDL assisted the U.S. Army Tank Automotive Command on developing fluidic damper valves; assisted the Navy on automated manufacturing methods for fluidic systems and backup flight controls; and assisted the Department of Transportation on a development project for a fluidic antilock braking system for motorcycles. In addition, HDL has begun to prepare a design guide for laminar-flow fluidics that will include a complete cataloging of all laminate configurations in HDL's recently adopted standard format (designated "C" format).

Fluidic Research

Laminar Proportional Amplifier (LPA) Research. Although a standardized design for an LPA has been established by scientists at HDL, research has nonetheless continued to examine its fundamental limits and capabilities. The standard LPA has been developed to give an optimum gain-bandwidth product while maintaining an input-to-output impedance ratio of greater than one. In many applications, however, bandwidth is not a

major concern. By increasing the distance traveled across the device, one can dramatically improve gain while maintaining a good input-to-output impedance ratio. The self-staged gain has thus been improved to 7, which is a 40-percent improvement over the standard design. Modeling of the LPA on NET-2 has continued to provide a user-oriented tool for systems design. This effort is near completion and should result in a working design system by mid-1982.

Laminar Jet Angular Rate Sensor (LJARS). The LJARS, combined with a multistage LPA as a preamplifier, forms a rate-sensing circuit that can be used in place of conventional rate gyroscopes. With an established resolution of 0.0005 °/s, the LJARS/LPA circuit has shown a dynamic range of 8 $\times$ 10^4. This capability is beyond available technology in pressure-to-electronic transducers. Concentration of effort has therefore shifted to devices suitable for a variety of transducer schemes. Evaluations have been conducted of piezoresistive as well as variable-capacitance pressure transducers.

An additional and innovative component which offers promise is the fluidic pressure-controlled oscillator (PCO). The PCO consists of an LPA with negative feedback; it oscillates as a function of the applied pressure. Studies have been conducted to improve the dynamic range of the PCO from less than 1,000 to over 10,000. This device offers a transducer alternative which will be insensitive to applied accelerations. The PCO has already shown application for missiles which do not require an extremely high dynamic range.

Additional studies have been conducted to improve the linearity and maximum rate of LJARS/LPA circuits. Goals are to achieve a linearity of better than 1 percent to 100 °/s.

Jet Deflection Servovalve. A no-moving-part jet deflection servovalve in the standardized integrated "C" format has been produced by scientists at the Massachusetts Institute of Technology, under contract to HDL. An increase in bandwidth over the already high bandwidth of the device has been achieved by the removal, through circuit integration, of parasitic impedances due to manifolds and interconnections. Preliminary environmental tests have indicated that the theoretical model is valid and that temperature dependence is small. This is because parameters such as gain depend on the ratio of the fixed resistors used to develop the servovalve function. Thus, even though the actual individual values of resistances may vary with temperature, as long as there is sufficient forward gain, the characteristics are independent of temperature. This is an important finding because quiet laminar or capillary resistors may be used to complete the circuit topology. This device will revolutionize hydraulic actuation servo systems by eliminating all moving parts except for the actuator. When coupled to the research on optical interfaces, research on this device will probably allow direct optical actuation of hydraulic circuits.

Electropneumatic Interface Research. Under contract to HDL, researchers at the University of New Hampshire have developed a reliable interface between electronics and fluidics, using the unique properties of piezo-bending crystals. These devices, which bend upon application of microwatts of electrical power, cannot support much force; as a result, they cannot be used in standard flapper-nozzle arrangements because the flow forces are too large. However, with the current availability of the LPA, low flows that generate negligible flow forces can be used in a flapper arrangement and the signal amplified fluidically to desired levels. Prototype hardware with a ±7 kPa (1 psi) output and a bandwidth of 1,000 Hz has been built and tested. The successful implementation of this device is expected to affect missile actuation systems operating with hot-gas fluidic controls, because the device will provide a reliable, low-cost, low-power-drain interface with the electronic flight computer.

Direct Photofluidic Conversion. The photofluidic device employs thermal energy conversion to convert light signals into fluid pressure signals. The first stage of the device is a photoacoustic cell, as shown in figure 1. Within the cell, a modulated light beam strikes a thermal absorbing target. The target surface then conducts heat to the adjacent gas, causing a modulated pressure within the cell. This acoustic signal generator drives a standard HDL fluidic LPA.

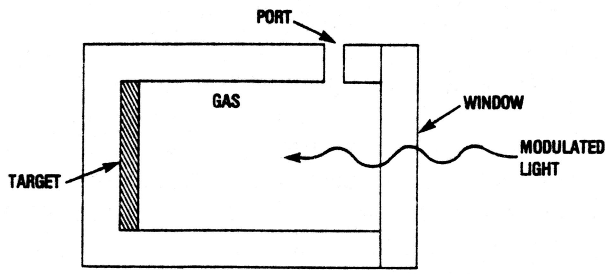


Figure 1. Photoacoustic cell.

Tests using standard LPA hardware have proven the usefulness of the cell combined with amplification. A one-stage LPA can typically amplify the original cell signal 2.5 times. Adding further amplifier stages to the LPA and a fluidic rectifier permits output of an analog dc pressure. The intended application of this multistage device will be at the receiving end of fiber-optic flight-control systems. Such a control system will employ no electronics beyond the photosignal generator. Other possible applications of this and similar photofluidic devices are as industrial controls where electrical energy is hazardous; as an improvement in signal-to-noise figures in the field of photoacoustic spectroscopy; and as a receiver for fiber-optic voice communication.

Fluidic/Electrical Interface Using Optical Techniques. Advanced fluidic applications, principally in the area of guidance and control, have required the development of pressure transducers with enhanced characteristics. Existing pressure-transducer technologies based on diaphragm displacement (capacitive, piezoresistive, etc) cannot meet the stringent requirements of these applications: wide dynamic range (40 dB), high sensitivity (in the differential mode, 0.001 mm Hg), and bandwidth (1 kHz). Consequently, under ILIR (In-house Laboratory Independent Research) funding, a project was conducted to research the feasibility of an optically based pressure transducer. The initial phase of this new research project investigates the pressure dependence of optical properties of applicable fluids with the typical limitations imposed by fluidic geometries. Molecular absorption, scattering, refraction, and fluorescence were shown to have a weak pressure dependence in typical fluidic environments (optical path lengths on the order of 1 mm). Although it is disappointing that a simple optical pressure transducer does not seem feasible even with the large capabilities of current detectors and associated electronics, this does not preclude other possibilities, such as optomechanical transducers or flow seeding.

Gas-Concentration Sensor. Under ILIR funding, HDL studied problems of unexplained signal drift and transient responses that affect steady-state operation in fluidic gas-concentration sensing circuits. A schematic diagram of the sensing circuit, which includes a chemical processor and a resistance bridge, is shown in figure 2. The results of analytical and experimental investigations indicated that the problems observed were caused by small leaks within the fluidic resistance bridge circuit. The presence of such leaks was verified by a unique test method that involved running two null offset curves (i.e., ΔP_0 versus bridge pressure, fig. 2). The first curve is for air drawn through the bridge from ground (ambient) to a negative potential (suction); the second is for air pushed through from a positive potential to ground. The direction of flow is the same for both cases, and only the presence of a leak caused the two curves to differ from one another. To minimize the possibility of leaks, the circuit was redesigned into an integrated package using standard "C" format laminates.

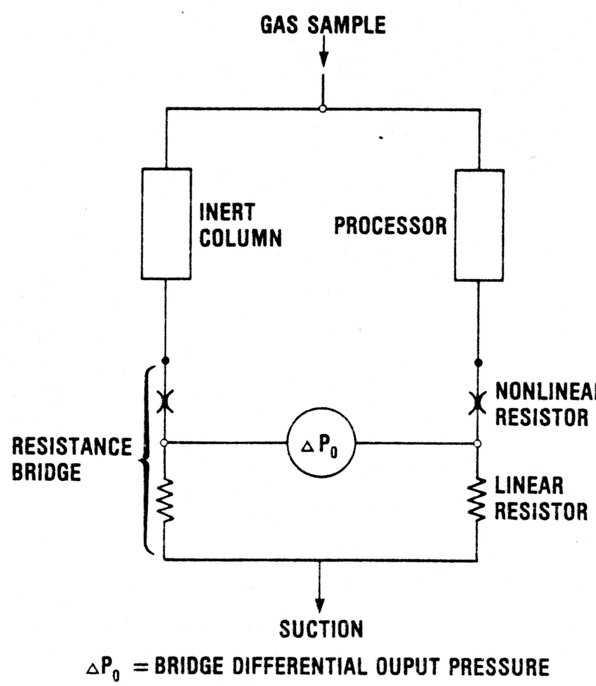


Figure 2. Concentration sensor schematic.

Exploratory Development

Fluidic Rate Gyroscope. HDL is sponsoring and technically managing a project to develop a medium-bandwidth fluidic rate gyroscope for missile systems. The heart of this rate gyroscope is the fluidic LJARS and a two-stage LPA. The LJARS/LPA circuit was designed for 80-Hz bandwidth operation and has a resolution of 0.1 °/s with a linear range of about 250 °/s. Also included in the system are an electrically powered reciprocating diaphragm pump to supply air to the fluidic circuit, and PCO's with microphone pickups to transduce the output signal. The entire rate gyroscope package, therefore, accepts an electrical input and provides an electrical output that is a measure of angular rate. Five single-axis rate gyroscopes (fig. 3) have been built for laboratory and environmental testing.

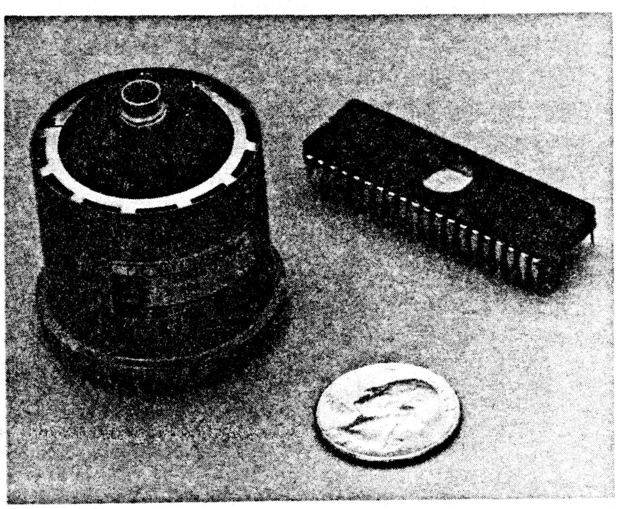


Figure 3. Fluidic rate gyroscope.

Fluidic Capillary Pyrometer. Advances in fluidic capillary pyrometer (FCP) technology during FY 81 include the design and fabrication of an FCP system for closed-loop automatic temperature control of a rotary hearth forging furnace (1,250° C) at the Scranton Army Ammunition Plant. Two FCP units installed for open-loop operation in FY 80 have accrued over 5,000 hours of thermal operating history. Subsequent evaluation of one unit after recall indicated no shift in sensor calibration (fig. 4). A pneumatic interface unit, which will allow the FCP to be coupled directly into the existing pneumatic furnace control system, has been designed and is presently in the hardware completion phase. The FCP, equipped with interface unit, offers a much simpler alternative because the temperature-sensing mechanism is now also pneumatic. Thermocouples currently used require transduction into a pneumatic signal, adding cost and reducing reliability. Figure 5 is a control circuit schematic showing optional FCP/thermocouple control modes to be used for direct comparison of the two systems.

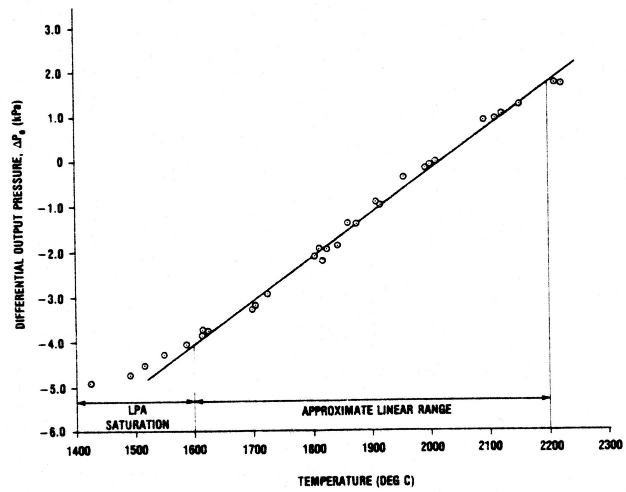


Figure 4. FCP calibration data.

Considerable progress has also been made in the field of ultra-high (>2,000° C) temperature contact thermometry under contract from Sandia National Laboratories. A two-channel FCP unit has been designed and fabricated for ultimate service to 2,750° C. An artist's concept of this system appears in figure 6. Under this program, probes made from tantalum will be used during a simulation of nuclear-core meltdown in molten urania (UO_2). On-site preliminary evaluation has yielded encouraging results at temperatures higher than 1,700° C. Data from an eight-hour segment of the test run are shown in figure 7. Note that one thermocouple failed midway through the test; however, the agreement between the FCP and the remaining thermocouple was good. Laboratory testing of the FCP at the National Bureau of Standards has shown repeatable performance to 2,240° C. The FCP measurement range is expected to be extended to 2,750° C in the near term. Figure 8 shows the FCP controller and probe.

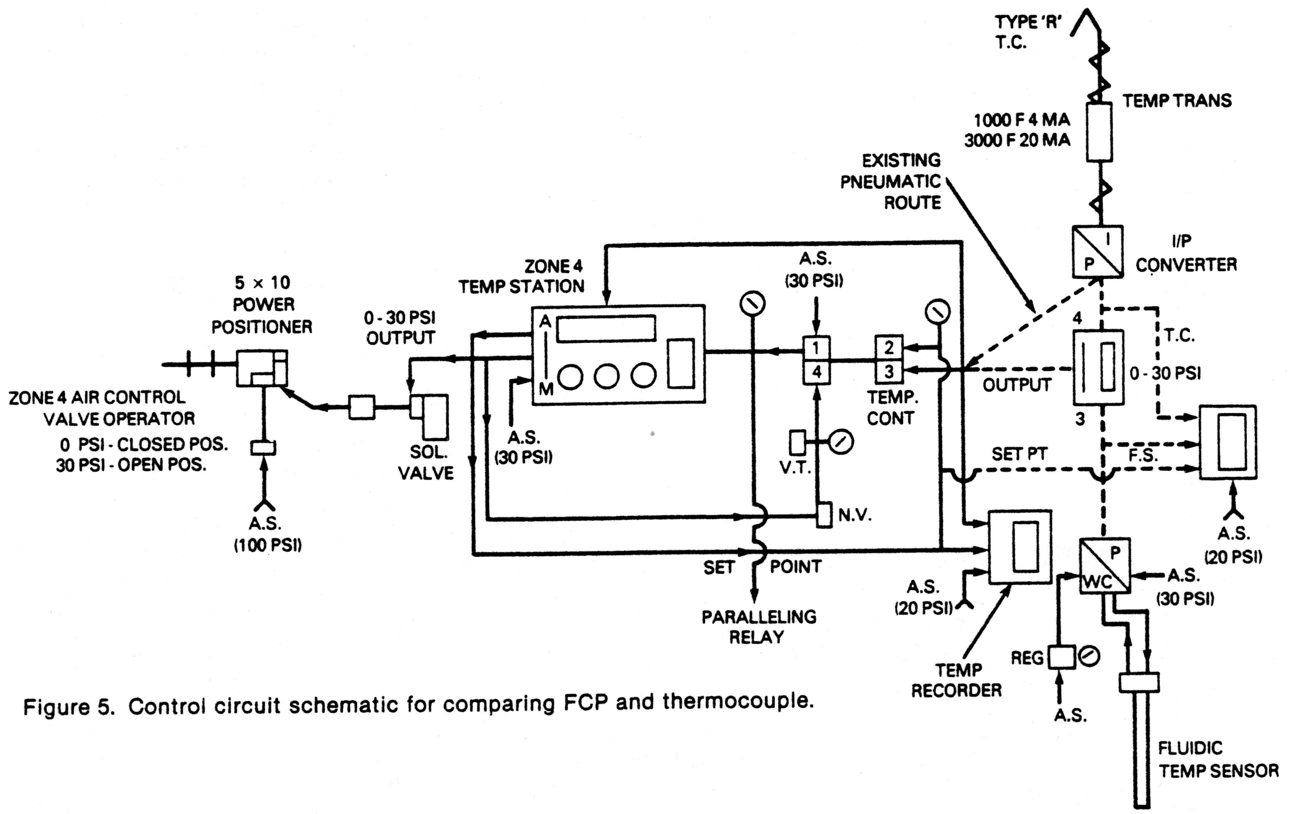


Figure 5. Control circuit schematic for comparing FCP and thermocouple.

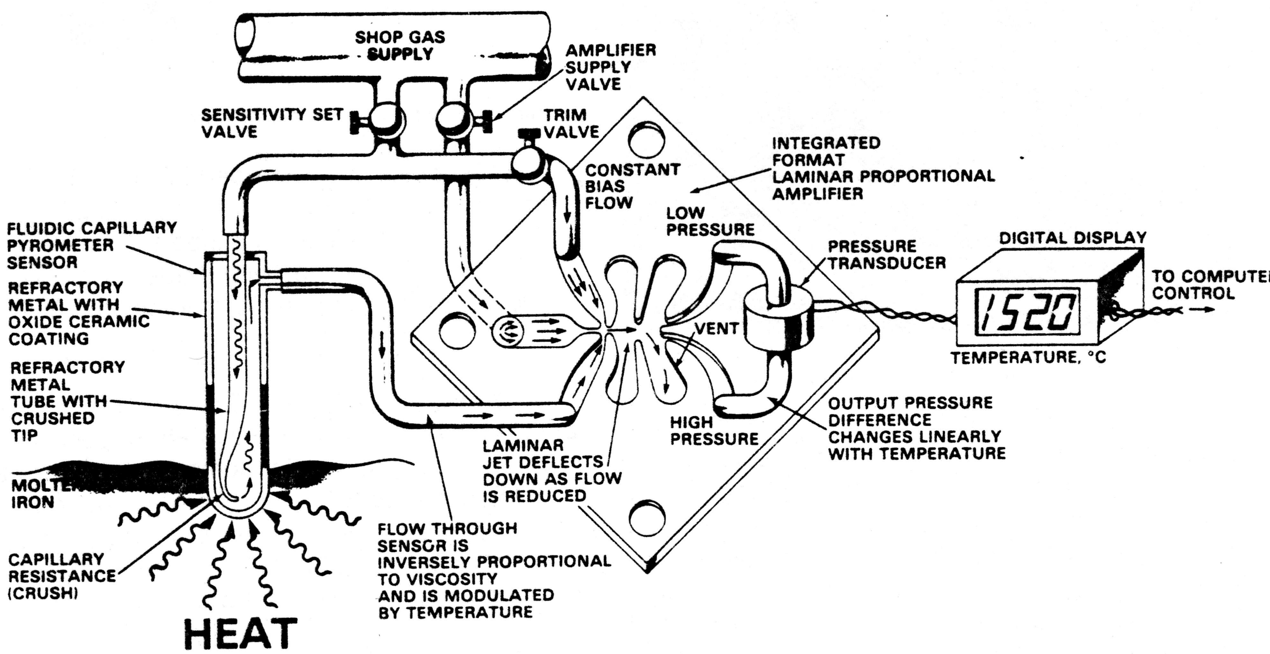


Figure 6. Artist's concept of high-temperature contact thermometry using FCP.

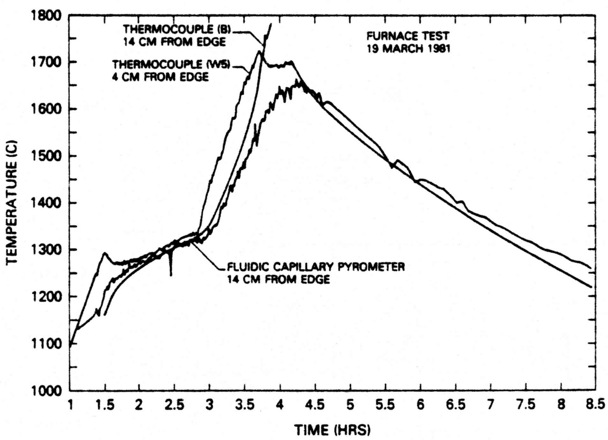


Figure 7. FCP test data.

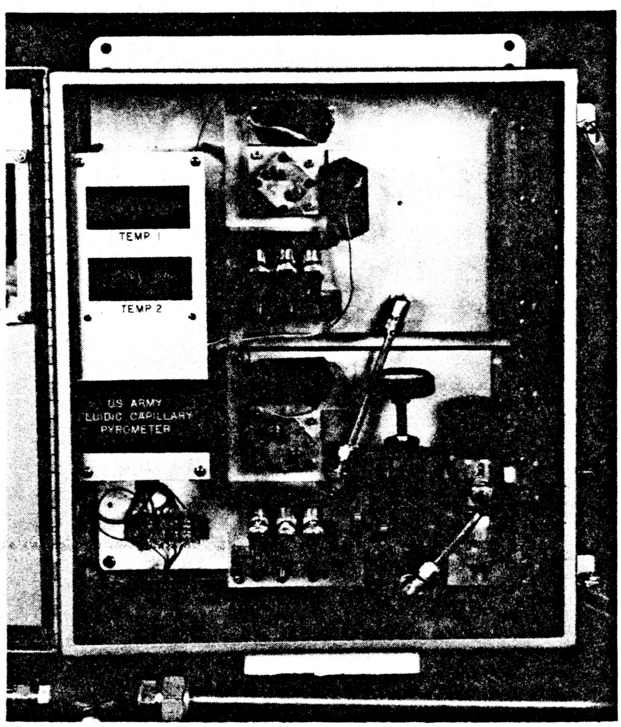


Figure 8. FCP hardware (controller and probe).

Mud-Pulse Telemetry. The overall objective of the program on mud-pulse telemetry, sponsored by the U.S. Geological Survey, is to improve the safety of hazardous offshore oil/gas drilling operations by providing a communications link between the bit and the surface during drilling. The specific objective is to develop a reliable, high-speed valve that can produce coded pressure pulses in the fluid (mud) which is commonly circulated through the hole to carry cuttings to the surface. Although mud pulsing is gaining acceptance in the field for transmitting slowly changing parameters such as hole direction and orientation, the slow response (less than 1 Hz) of the mechanical valves used in these systems does not permit transmission of the quality of data needed to effectively improve drilling safety.

HDL has successfully demonstrated the operation of a full-scale fluidic mud-pulser valve at pulse rates up to 10 Hz. The tests were conducted under simulated drilling conditions at the Terra Tek Drilling Research Laboratory in Utah. The test hardware (fig. 9) was designed for use with standard drill pipe at well-bore pressures up to 10,000 psi (68,940 kPa). During the test, the valve was operated with water and drilling muds while average and transient pressures were measured.

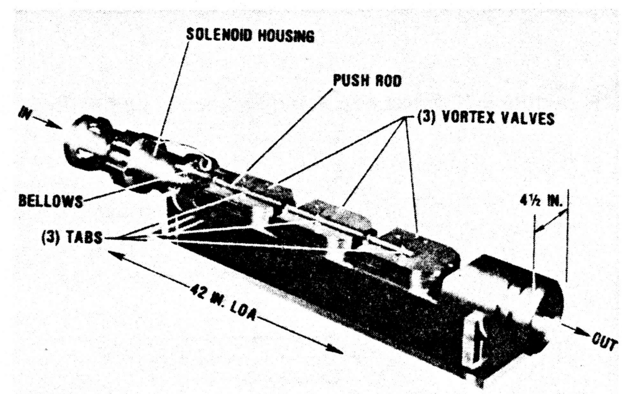


Figure 9. Fluidic mud pulser hardware.

Because of the considerable interest in this program exhibited by the drilling industry, along with offers of testing support in the field, preliminary plans have been made for a full-scale demonstration of the fluidic mud-pulser valve during drilling.

Manufacture of Fluidic Components. Several processes have been investigated for possible use in manufacturing fluidic components. Emphasis has been on identifying processes that can produce accurate, repeatable fluidic amplifiers and other critical elements which are required for many of the current development projects.

One project, funded through the Army's Manufacturing Methods and Technology program, supplemented earlier Army and Navy projects that

investigated fineblanking of fluidic laminates.[1,2] The HDL standard LPA with a power nozzle of 0.5 mm, vent plates for this LPA, and dropping resistors were fineblanked in the HDL standard laminate format. All three of these laminates are considered critical for assembling a quantity of fluidic circuits with predictably repeatable performance. Test results verified that the LPA's and dropping resistors exhibited better repeatability than equivalent parts that were chemically etched.

HDL also had smaller projects to investigate the use of injection molding and laser cutting for making fluidic LPA's. Initial parts from the injection mold displayed good surface finishes, especially on the vertical walls. However, dimensional errors in the mold precluded meaningful quantitative results. A few sample LPA laminates were made by laser cutting. These parts produced an amplifier silhouette with a scallop-like appearance; this result indicates that laser cutting needs further development to be suitable for fabricating fluidic parts.

Fluidic Generator. The Jet Propulsion Laboratories (JPL) has undertaken a two-year project which involves the development of a mathematical model of the onset of sustained oscillations in a short-tube, knife-edge cavity configuration over subsonic and supersonic regimes. This research provides general support for such systems as the fluidic generator that can be used in numerous fuzing applications for the tri-service community. Although the primary concern has been a fluidic generator for the Multiple-Launch Rocket System (MLRS), this work would be applicable to all future fuzing programs.

During the second year of this effort, JPL developed a high-alititude test facility for testing the generator. This facility can provide supersonic flow through the generator at simulated altitudes up to 90,000 ft (27,500 m). The mathematical model and high-altitude test facility were used to determine the design changes needed to improve the generator's input at high altitude. A standard generator was modified to incorporate the design changes. Tests of the modified unit showed a substantial improvement in generator output. The increased output was greater at higher altitudes and flight Mach numbers.

[1] *Lester Pecan, Fineblanking, Diffusion Bonding, and Testing of Fluidic Laminates, TriTec, Inc., Columbia, MD, under contract to Harry Diamond Laboratories, HDL-CR-80-074-2 (July 1980).*

[2] *L. E. Scheer, J. S. Roundy, and J. W. Joyce, Manufacturing Techniques for Producing High Quality Fluidic Laminates in Production Quantities, Proceedings of the 20th Anniversary of Fluidics Symposium, ASME (1980).*

surveillance and target acquisition

Radar Technology. The development of the technology base in support of personnel- and vehicle-detection radar is a large part of ERADCOM's ISTA (intelligence, surveillance, and target acquisition) mission. Program objectives are to provide the technology required to produce low-cost, automatic, reliable battlefield surveillance and target-acquisition systems. The systems must have the capabilities of foliage penetration, low electronic countermeasure (ECM) vulnerability, all-visibility operation, and high battlefield survivability. Since tactical radars are vulnerable to electronic location devices as well as to anti-radiation missile (ARM) attacks, consideration is being given to a tactical multistatic radar system to perform the surveillance and acquisition mission.

In late FY 80, a joint Army (ERADCOM)/DARPA program was initiated to develop and field test a bistatic alerting and cueing (BAC) system for passive surveillance and acquisition of ground and air targets. The program's objective is to verify the BAC concept experimentally in a brassboard configuration that exploits existing battlefield surveillance radars, such as AWACS (airborne warning and control system) and SOTAS (standoff target-acquisition system). The study phase of the BAC program was completed at the end of FY 81. Two contractors were involved in the study phase, and one of these was selected to build the brassboard unit for field test and evaluation. The evaluation tests are scheduled for the summer of 1983. In support of the field evaluation of the BAC concept, the DARPA-sponsored advanced ground surveillance radar (AGSR) system has been obtained by HDL on loan from Lincoln Laboratories. The AGSR will also be used to study the technology associated with the development of a knowledge-based expert target classifier.

In addition to BAC, programs have been established in synthetic aperture radar (SAR), foliage-penetration radar (FOPEN), and millimeter-wave ground-surveillance radar (MMW GSR). In the SAR program, a complete procurement package (request for proposals) was prepared, the initial system concept studies were completed, and the program is now awaiting funds from DARCOM. In the FOPEN program, the initial studies have been completed, and a program has been defined. Funding priorities have delayed start of the FOPEN work. In the MMW GSR program, an evaluation of the PPS-15 has been performed to establish a baseline for the design. MMW components are on order, and during FY 82 a test bed system will be fabricated and evaluation will begin.

devices and technology

Acousto-Optic Time-Integrating Correlator. Real-time cross-correlation of broadband signals has been demonstrated using one- and two-dimensional acousto-optic time-integrating correlators. Major progress has been made in packaging this into a 17 × 24 in. (43 × 61 cm) rack-mountable processor. Further size reduction requires the use of gallium-aluminum-arsenide cw laser diodes. The diodes have been tested and have satisfactory coherence and line width to accomplish interferometric cross-correlation.

Heterodyne Detection Bragg Cell. An ultra-fast Bragg cell spectrum analyzer has been constructed. The device uses a specially constructed fiber-optic detector array for obtaining fully channelized real-time output and heterodyne detection, both for achieving fast response of short-duration pulses and for preserving relative phase between the various channels. Broadband signals have been reconstructed by combining the output channels. Adaptive filtering of cw interferers has also been demonstrated using this technique. A large linear dynamic range and rise times of a few hundred nanoseconds have been achieved.

Acousto-Optic Implementation of Modified Cepstrum Processor. An acousto-optic implementation of a modified Cepstrum processor has been achieved. A surface-acoustic-wave ultrasonic delay is used to modulate a laser beam which, together with a Fourier transform lens, produces the Fourier transform of an rf signal at the lens back focal plane. An integrating charge-coupled device photodetector array detects the signal and also limits large-amplitude cw signals. A digitally generated inverse Fourier transform of the photodetector output produces a correlation of the original rf signal, which can be used to provide time-difference-of-arrival information.

penetration of obscurants

Near-Millimeter-Wave (NMMW) Radar. A high-performance, short-range radar in a small lightweight package is a goal of the NMMW ground-surveillance radar program at HDL. During FY 81, a 94-GHz test-bed radar was designed and implementation was begun for pulsed coherent and noncoherent modes of operation. A slotted waveguide array antenna feeding a cylindrical reflector produces a $0.5^{\circ} \times 1.5^{\circ}$ beam. This antenna will be used with the test bed radar to perform Phase I performance evaluation and signature data collection. A low-power flat display system with microprocessor-controlled memory scan and update was designed, and a development model was fabricated and tested.

Cerenkov NMMW Source. This work seeks to demonstrate the feasibility of producing an intense source of NMMW radiation based on the Cerenkov effect. In this device, electrons are emitted thermionically from a cathode held at a negative dc potential of 200 kV by a power supply capable of up to 50 kW. The electron beam passes through a metallic waveguide having a dielectric linear resonator made of fused quartz. Cerenkov interaction and beam-wave coupling occur in the region of the resonator, since the electron energy greatly exceeds the Cerenkov threshold for fused quartz. The resulting NMMW radiation emerges from the window at the end of the waveguide, while the electrons are collected on the water-cooled section of waveguide wall immediately preceding the window. Because the electron beam is cw, the signal will be virtually noise-free, so that the dependence of the NMMW output on various important parameters should be accurately measurable. These parameters include electron-beam voltage and current, dielectric geometry, and the closeness of the beam to resonator walls. Judging from theoretical and experimental work at Dartmouth College, the Cerenkov device should be capable of kilowatts of NMMW power with an efficiency greater than or equal to about 10 percent. Voltage holdoff tests have been performed in an effort to design an appropriate cathode-to-anode insulating tube. In order to insure that the electron motion is completely axial, a guide magnetic field provided by two solenoids will be used. A table to support these solenoids and a Hall-probe jig were fabricated so that this field can be accurately aligned to the axis of the beam tube. Major components still to be fabricated are the electron gun, a filament supply, a vessel at ground potential enclosing this housing and filled with insulating gas, the waveguide containing the dielectric resonator, and a water-cooled beam dump.

NMMW Detectors/Mixers. In the microwave/millimeter portion of the spectrum, diode detection is most common and photoconductive devices are nearly unheard of. In the NMMW region, however, both types of devices are common and photoconductive devices generally yield significantly improved detection sensitivity. Although cryogenic operating temperatures are required, for numerous applications this factor is more than compensated by the fact that photoconductive detectors are more rugged, easier to fabricate, more reproducible, and less expensive than diode devices. In addition, it is reasonable to expect that the well-known visible/infrared sensitivity of numerous photoconductive materials offers, when combined with sensitive NMMW interactions, the possibility for development of a hybrid detector, sensitive over a very broad portion of the spectrum.

Recently HDL reported the first observation of photoconductivity from free-carrier absorption of broadband, near-millimeter radiation in mercury cadmium telluride. Figure 1 shows recent results achieved by varying the cadmium mole fraction, x, and mobility in n-type ($Hg_{1-x}Cd_x$)Te. Compared to our earlier results, a 50-fold increase in responsivity has been obtained and, for the first time, it has been possible to clearly observe I-V trace nonlinearity attributable to hot-electron phenomena in mercury cadmium telluride. At 1.5 K and 105 GHz, the responsivity is 50 V/W, corresponding to a Johnson-noise-limited video noise equivalent power of 1.4 × 10^{-1} W/Hz. In addition, when used as a mixer, the HgCdTe element has a 3-dB bandwidth of 25 MHz at 1.5 K, significantly extending the 1-MHz speed limitations currently observed for indium-antimonide photoconductive elements.

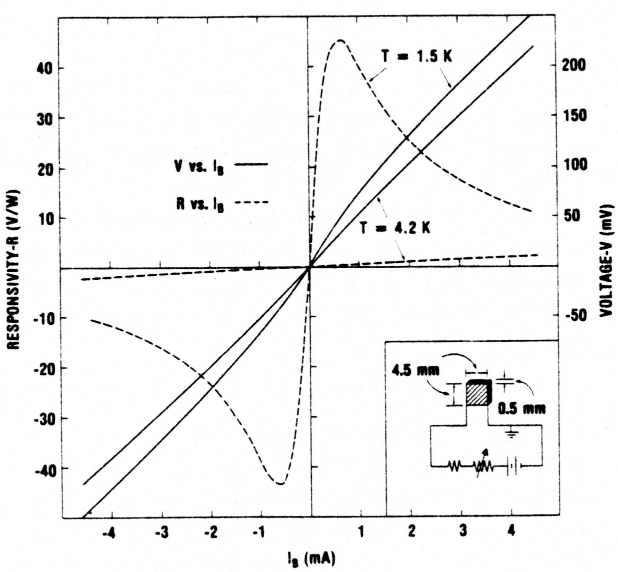


Figure 1. HgCdTe detector responsivity at 105 GHz (dashed lines) and crystal dc voltage (solid lines) versus bias current at 1.5 and 4.2 K.

Ultrahigh Resolution Spectroscopy/Optically Pumped NMMW Sources. Infrared (IR) diode-laser heterodyne spectroscopy was performed on sulfur dioxide and carbonyl sulfide. Analyses of the spectra were done in collaboration with the National Bureau of Standards. The resultant spectroscopic constants of sulfur dioxide were used to predict and assign the 15 new NMMW emission lines discovered at HDL (table 1). Measurements of the line widths of carbonyl sulfide IR absorptions versus pressure were made with the diode laser heterodyne spectrometer. The results were used to determine parameters in a refined theory of pressure broadening for linear molecules.

The thrust of the year's optically pumped NMMW source effort was centered around the use of a tunable CO_2 waveguide laser to pump the NMMW laser. The interest in using a CO_2 waveguide pump laser is twofold. First, the sealed-off rf-excited CO_2 laser is considerably more compact than the conventional pump laser. The reduced size allows for easier application of the optically pumped sources outside the laboratory. Second, the high-pressure waveguide laser has a greater frequency tunability than the conventional CO_2 laser. This desirable feature permits optimal pumping of already known submillimeter-wave laser lines with large IR absorption frequency displacements from the CO_2 line center. The greater frequency tunability also should lead to the discovery of many new laser lines. HDL has used the waveguide laser to pump several select gases already known to be good NMMW laser sources. These include 1,1-difluoroethylene ($C_2H_2F_2$), deuterated methylene fluoride (CD_2F_2), and deuterated fluoroform (CDF_3).

Thirty discrete laser frequencies were observed by pumping with the waveguide laser. We can separate the observations of these 30 lines into three categories of pump frequency offsets. First, the "strongest" lines previously pumped with conventional CO_2 lasers were observed and found to correspond to relatively small absorption frequency offsets ($\leqslant$40 MHz). Second, considerably lower pump thresholds and greater NMMW power were found for some previously observed "weaker" lines with relatively large frequency offsets of approximately ±65 MHz from CO_2 line center. In the final case, corresponding to typical frequency offsets of greater than 70 MHz, we found 17 new laser lines which are well beyond the tuning range of a conventional CO_2 laser. The absorption frequencies and some assignments were made in conjunction with the infrared diode-laser heterodyne measurements. In figure 2, a frequency scan across the CO_2 waveguide laser tuning profile (up-

Table 1. Optically Pumped NMMW Emissions from $^{32}S^{16}O_2$

$\bar{\nu}$ (cm^{-1}) measured	$\bar{\nu}$ (cm^{-1}) calculated	NMMW assignment	$^{12}C^{16}O_2$ pump	Reference
28.65(3)	28.650598(12) or 28.677637(12)	$37_{9,29}-37_{8,30}$ or $36_{9,27}-36_{8,28}$	9R(40) 9R(40)	*a*
32.07(7) 32.08(3)	32.090581(13)	$37_{10,28}-37_{9,29}$	9R(40)	*b* *a*
38.67(15)	38.827268(17)	$37_{12,26}-37_{11,27}$	9R(28)	*b*
48.71(10) 48.72(7)	48.676559(19)	$36_{15,21}-36_{14,22}$	9R(14)	*b* *a*
51.79(6)	51.644075(21)	$36_{9,27}-35_{8,28}$	9R(40)	*a*
55.4(8)	55.037842(21)	$24_{17,7}-24_{16,8}$	9R(18)	*a*
55.56(31)	55.672402(22)	$37_{10,28}-36_{9,27}$	9R(40)	*b*
58.58(24)	58.414712(23)	$36_{11,25}-35_{10,26}$	9R(28)	*a*
60.53(7)	60.602394(29)	$29_{13,17}-28_{12,16}$	9R(26)	*a*
62.3(6) 62.50(31)	62.380686(23)	$37_{12,26}-36_{11,25}$	9R(28)	*b* *c*
64.43(8)	64.508745(29)	$30_{14,16}-29_{13,17}$	9R(26)	*a*
66.80(40)	66.489282(28)	$23_{16,8}-22_{15,7}$	9R(18)	*a*
68.40(33)	68.332583(24)	$36_{14,22}-35_{13,23}$	9R(14)	*a*
70.32(31) 70.32(14) 70.47(29)	70.315161(23)	$24_{17,7}-23_{16,8}$	9R(18)	*c* *b* *a*
70.37(59)	70.3081	$39_{14,26}-38_{13,25}$[d]	9R(28)	*a*
71.48(15) 71.58(26)	71.583447(23)	$36_{15,21}-35_{14,22}$	9R(14)	*b* *c*
78.06(36)	77.8990	$26_{19,7}-25_{18,8}$[d]	9R(18)	*a*
79.11(6)	79.169544(23)	$28_{19,9}-27_{18,10}$	9R(34)	*a*

[a] *TEA laser pump.*
[b] *cw pump.*
[c] *A. R. Calloway and E. J. Danielewicz, Aerospace Corporation.*
[d] *Ground state transition.*

per curve) shows the positions where NMMW laser action occurs for two new $C_2H_2F_2$ lines pumped by the 10P22 line. The dips in the NMMW output (lower curve) indicate a saturation effect at the absorption line center.

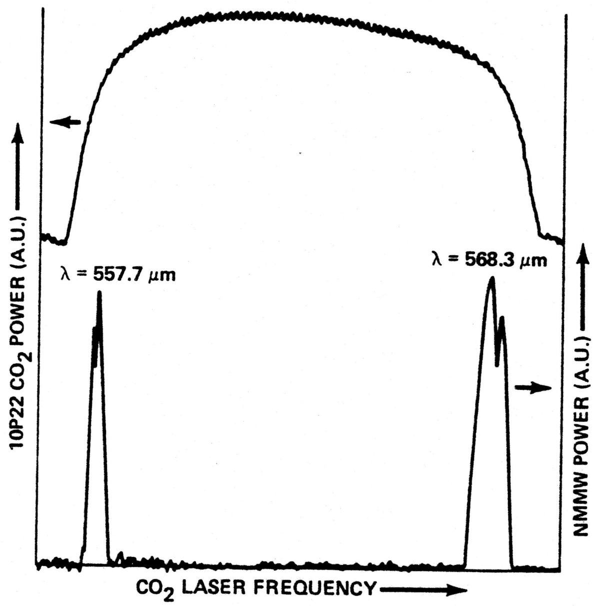


Figure 2. Upper trace: CO_2 waveguide laser tuning profile for 10P22 line. Lower trace: NMMW output shows 558-μm line with pump frequency offset of −117 MHz and 569-μm line with pump offset of +87 MHz from CO_2 line center.

NMMW Materials. The NMMW properties of thin films of doped GaAs on high-resistivity GaAs substrates were studied in transmission by use of a Michelson interferometer and an optically pumped laser (fig. 3). These GaAs films are of interest for many semiconductor device applications and were prepared by the molecular beam epitaxy process. Films of various thinness and carrier concentration were examined. The measured transmission was compared to that calculated from the Druede free-carrier model. Significant discrepancies were found that are attributable to impurity scattering and film geometry.

Studies were made by a variety of quasi-optical techniques on other materials important for NMMW systems. These include the ferroelectrics lithium niobate and lithium tantalate, sapphire, silicon, fuzed and crystal quartz, alumina, beryllia, and TPX plastic.

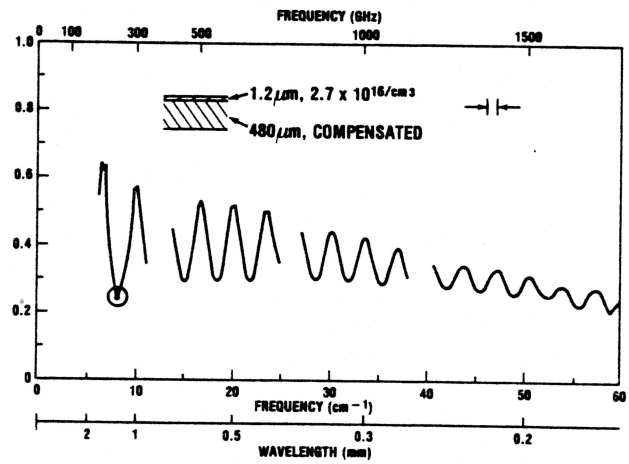


Figure 3. Measured transmission spectra of GaAs.

NMMW Mobile Measurement Facility. An NMMW mobile measurement facility (MMF) has been developed by HDL to obtain basic data on propagation and target/background characteristics. The NMMW/MMF consists of two semi-trailers that contain transmitters and receivers at 96, 140, and 225 GHz. The system is operated from available commercial power or portable 30-kVA generators. One trailer is termed the "transceiver van" and contains high-power, pulsed transmitters operating at the three frequencies. The transmitter tubes are extended-interaction oscillators, the best commercially available high-power pulse tubes for this frequency range. Three heterodyne receivers employing the latest NMMW technology are also contained in this van for backscatter measurements from targets or hydrometeorites. The data-sampling rate is variable with 800 Hz maximum. A data-acquisition system with video readouts allows 128 positionable 7.5-m range gates to be displayed or recorded. This van also contains an HP-1000 minicomputer for digital processing, magnetic tape recording, and control of the experiment.

The second trailer, termed the "receiver van," contains three video receivers for measurement of direct transmission and bistatic reflectivities. Data

collected at the receiver van are automatically transmitted to the transceiver van for processing and recording. All transmitters and receivers have separate 61-cm diameter Cassegrain antennas whose heights, orientation in azimuth and elevation, and polarizations are adjustable.

The NMMW/MMF was designed and built for HDL by the Georgia Institute of Technology Engineering Experiment Station. During January and February 1981, HDL staff measured transmission and backscatter in falling snow at the SNOW-ONE tests conducted in Vermont by the U.S. Army Cold Regions Research and Engineering Laboratory. Figure 4 shows the transceiver van in position for making measurements at the test. During a 9-in. snowfall, measured attenuation coefficients were largest at 225 GHz and least at 96 GHz. Correlation between attenuation coefficients and snow mass concentrations was found to exist for all three frequencies. Backscatter cross sections per unit volume for falling snow were measured to be between 1 and 7×10^{-5} m^2/m^3 at 96 GHz for water-equivalent snow mass concentrations between 0.1 and 0.6 gm/m^3.

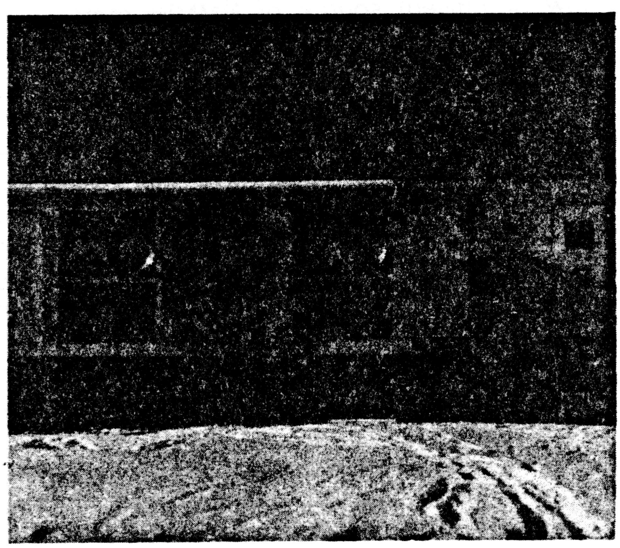


Figure 4. NMMW/MMF transceiver van at SNOW-ONE test.

NMMW Gyromonotron. HDL, in a collaborative effort with the Naval Research Laboratory (NRL), has built and operated a source of high-power NMMW radiation called a gyromonotron. It is a tube based on the cyclotron resonance maser principle, in which electrons gyrating at the cyclotron frequency in an applied magnetic field impart some of their energy to the electromagnetic wave in an rf cavity. The HDL-NRL tube, by operating at the second harmonic, is able to produce 238-GHz radiation with an applied field of 45 kG from a superconducting magnet. The electron beam is produced by a specially designed gun, called a magnetron-injection electron gun, which operates at 30 kV and produces up to 1.3 A. After emerging from the rf structure, the NMMW radiation leaves the vacuum through a fused-quartz resonant window, whereas the electrons are collected on the waveguide walls by a diverging magnetic field. Using a calorimeter and various crystal detectors, radiation with a peak power of about 50 W was observed at a magnetic field of about 45 kG and about 200 W at about 46 kG. Frequency measurements with Fabry-Perot interferometers built at HDL indicate that the former is second-harmonic radiation at 238 GHz with a bandwidth of a few megahertz, and the latter is first-harmonic radiation at about 120 GHz. Although both these radiations and the values of magnetic field at which they occur are consistent with theory, the output power of the 238-GHz radiation is much lower than the 1.4 kW predicted for this tube. It is believed that changes in the rf structure to be made in future experiments will increase the output power toward the predicted value.

NMMW Antennas. The Army's first monolithic conformal linear phased-array antenna has been fabricated at HDL. Designed for 94 GHz, the array consists of 28 rectangular microstrip elements etched on 127-μm PTFE substrate using standard printed-circuit technology (see fig. 5). Measured results indicated a 3° beam width with sidelobes down about 10 dB from the peak of the beam. The antenna was designed using an interactive computer code, which was also developed at HDL to analyze microstrip antennas. As a better understanding of NMMW transmission in thin plastic substrates is developed, it is anticipated that improved conformal antenna designs at 94 GHz will be possible.

Diffraction Electronics. A tunable, highly coherent source of NMMW radiation, new to the western world, has been developed and tested this

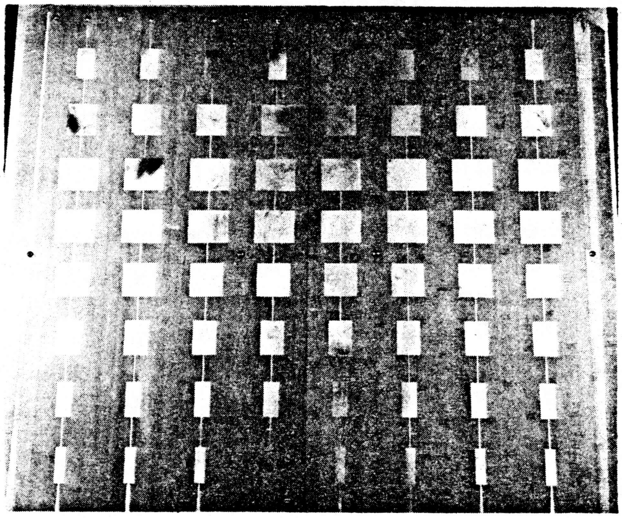


Figure 5. Phased-array microstrip antenna.

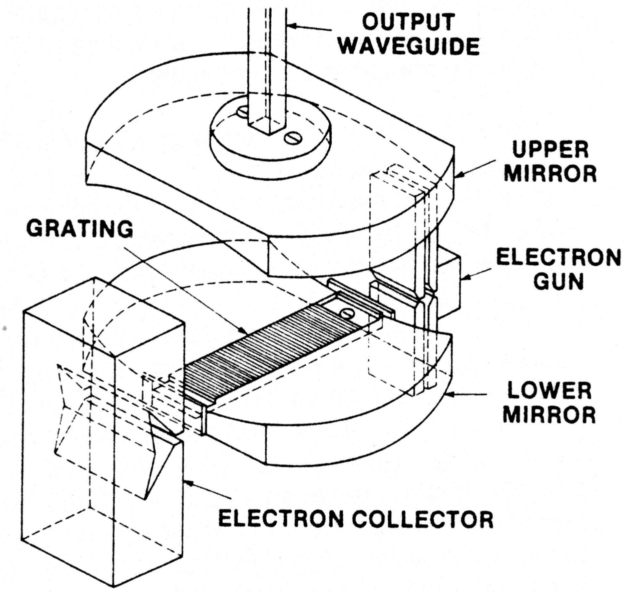


Figure 6. Orotron.

year at HDL. This device, which is called an orotron (a name originating from its use of an open resonator), consists of a ribbon-beam-producing electron gun and a metallic diffraction grating enclosed in the open resonator (see fig. 6). As shown in the figure, the electron beam passes just over the grating surface and generates electromagnetic radiation that is enhanced within the open resonator at resonance conditions; these conditions are determined by the separation of the upper and lower mirrors and by the beam voltage. This device has been operated on four different modes and was tuned continuously on a single mode from 53 to 75 GHz. This tuning was accomplished by simultaneously varying the beam voltage and mirror separation. Interesting features of the orotron which were also found in this work are that the output power is highly monochromatic and that this device can produce sharp, 100-ns pulses at a high repetition rate by the use of low-voltage signals applied to the grating. Other properties of the device that may make it particularly attractive for military applications are that it can be made into a portable, efficient, intermediate-power (cw or pulsed) source of NMMW radiation, for penetration of battlefield obscurants.

In addition to the above experimental work, recent advances in the theory, developed at HDL, suggest that a more dense beam (denser by a factor of five than the one presently used in the interaction region) should allow an orotron to produce several hundred watts of cw or pulsed power at efficiencies comparable to those of gyrotrons (15 percent or better). Beams of these densities can be produced with present technology in a focused magnetic field by shaped, permanent magnets, where the field would serve to converge and guide the beam across the grating. Experimental and theoretical studies that will contribute toward improved NMMW orotrons are continuing at HDL.

electronic and signals warfare

Anti-Radiation Projectile Sensor. The sensor for the anti-radiation projectile (ARP) began advanced development at HDL in February 1979. ARP, the initial Army configuration of the 8-in., extended-range guided projectile (ERGP), is being developed by the Office of the Project Manager for Cannon Artillery Weapons Systems (PM-CAWS), Dover, NJ. Functionally, the sensor includes an rf receiver and direction-finding system, as well as analog and digital circuitry required to detect and sort targets. The sensor selects a predetermined signature from its received signals and delivers direction instructions to the autopilot, which then guides the projectile toward the emitter. The Naval Weapons Center (NWC), at China Lake, CA, has been funded by HDL for the initial electrical brassboard design of the ARP sensor, to insure that full advantage will be taken of the extensive experience in anti-radiation sensors available at NWC. HDL is proceeding with the fully configured design of the system, which comprises technologies in microwaves, IF, video, microcomputers, miniaturization, and complex software control systems. Fully configured gun-hardened units will be fabricated in-house to serve as models for an engineering development contractor. Investigations of both active and passive fuzing techniques are also being undertaken.

Anti-Radiation Missile Countermeasures (ARM-CM). The objective of the ARM-CM program is to develop effective means of reducing the vulnerability of Army ground-based and airborne emitters (such as radar, communication, navigation, and jammer systems) to attack by enemy ARM systems. The major areas of effort are as follows:

- evaluation of intelligence data and U.S. ARM seeker technology to model and simulate the present and future ARM threat,

- development of CM technology, techniques, and prototype hardware,

- evaluation of CM technique effectiveness using computer modeling, laboratory, and field tests,

- development of instrumentation systems to evaluate the laboratory and field performance of threat ARM seekers and CM systems,

- support of project managers in ARM vulnerability and ARM-CM effectiveness analysis and testing,

- evaluation of the interaction of tactics, scenario, and CM techniques, and

- dissemination of ARM-CM techniques to the tri-service and NATO community.

One of the principal tools used in the evaluation of ARM-CM technology and techniques is digital simulation. The central role of simulation is shown in figure 1, which also illustrates the flow and interdependence of information developed in the different parts of the program. Evaluation of intelligence data is aided by comparison with U.S. ARM technology to permit the definition of both confirmed presently fielded and estimated future threat ARM models. Present and future friendly emitters and CM system models are also

developed to permit the performance of an attacking threat to be determined. The improvement in survivability of the system provided by CM tactics and hardware is then evaluated.

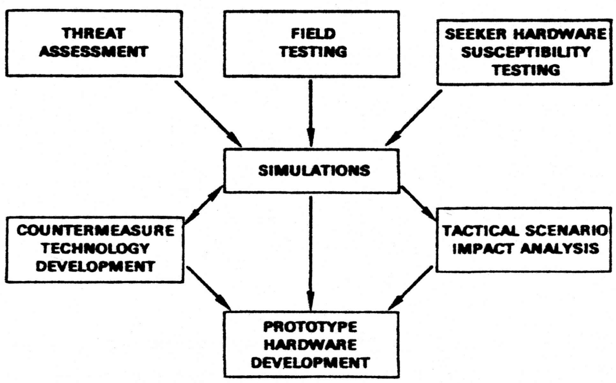


Figure 1. Flow of information in ARM-CM program.

Laboratory testing is used to check the accuracy of the computer models for specific phases of an attack. Some of these laboratory tests have been made using the Radio Frequency Simulation System (RFSS) at the Advanced Simulation Center, MICOM. The ARM-CM program supported the development of a "generic" ARM seeker for use in this test facility which is adaptable enough to simulate both friendly and enemy analog ARM seekers. The ARM-CM program is now planning for the development of an advanced generic seeker so that in future, the hardware will exist to simulate the estimated new ARM threats which may include dual-mode seekers (e.g., rf/IR), advanced concept seekers (e.g., mainbeam signal tracking ARM's which may employ navigation systems), and seekers which employ digital processing.

Field tests have been run this year against the Firefinder Artillery Locating Radar (AN/TPQ-37), using the airborne version of the generic seeker which feeds data to an instrumentation pod that the ARM-CM program had developed. This fighter-aircraft-mounted system can simulate the acquisition, lock-on, and track phases of ARM seekers. This generic ARM seeker was modified this year to permit it to operate in a pulse-to-pulse adaptive signal-intensity threshold-control mode. The ARM-CM program has also provided a static instrumentation platform (a helium-type barrage balloon) for the seeker, to allow spot checks of the seeker's behavior in the critical near-end-game portion of the attack at realistic altitudes, where the test aircraft cannot be used safely.

Two types of prototype ARM-CM decoys are now being developed under the direction of this program. Lightweight magnetrons are being developed for an active decoy which is manportable, contains its own generator and fuel storage system, is low in cost, and is physically small. Its small size makes it easier to protect using sand bags and to conceal. A passive decoy is also being developed which is expected to be an effective, low-cost, lightweight, and unusually survivable ARM-CM.

Both the chairman and the Army representative for the Tri-Service Joint Working Group in ARM-CM are provided by HDL. In support of the tri-service group, HDL annually hosts a Tri-Service ARM-CM Symposium.

Artillery-Delivered Unattended/Expendable Communication Jammer. The Unattended/Expendable Jammer (UEJ) is being developed by HDL under the sponsorship of the Signals Warfare Laboratory (SWL). The program objectives are to design, develop, and field qualify a low-cost, gun-rugged, expendable communication jammer.

The UEJ is a barrage communication jammer designed to be delivered by 155-mm artillery to seed an area behind enemy lines. During deployment, the jammers are ejected one at a time from the cargo projectile as it travels along the flight trajectory. Following ground impact, the antenna/ground plane assembly is deployed and the transmitter turned on. The UEJ, which operates in the lower vhf range, will disrupt and confuse enemy tactical communications.

During the first quarter of FY 81, functional full-up jammers were successfully gun fired at Yuma Proving Grounds (YPG). Figure 2 is a photograph of a UEJ assembly which survived the gun-firing environment, erected its antenna/ground plane, and transmitted the required power. A contractor was selected to fabricate the DT/OT-I test hardware. Prototype assemblies fabricated at the contractor's plant have been field tested, and assembly of DT/OT-I hardware is scheduled to start in early FY 82.

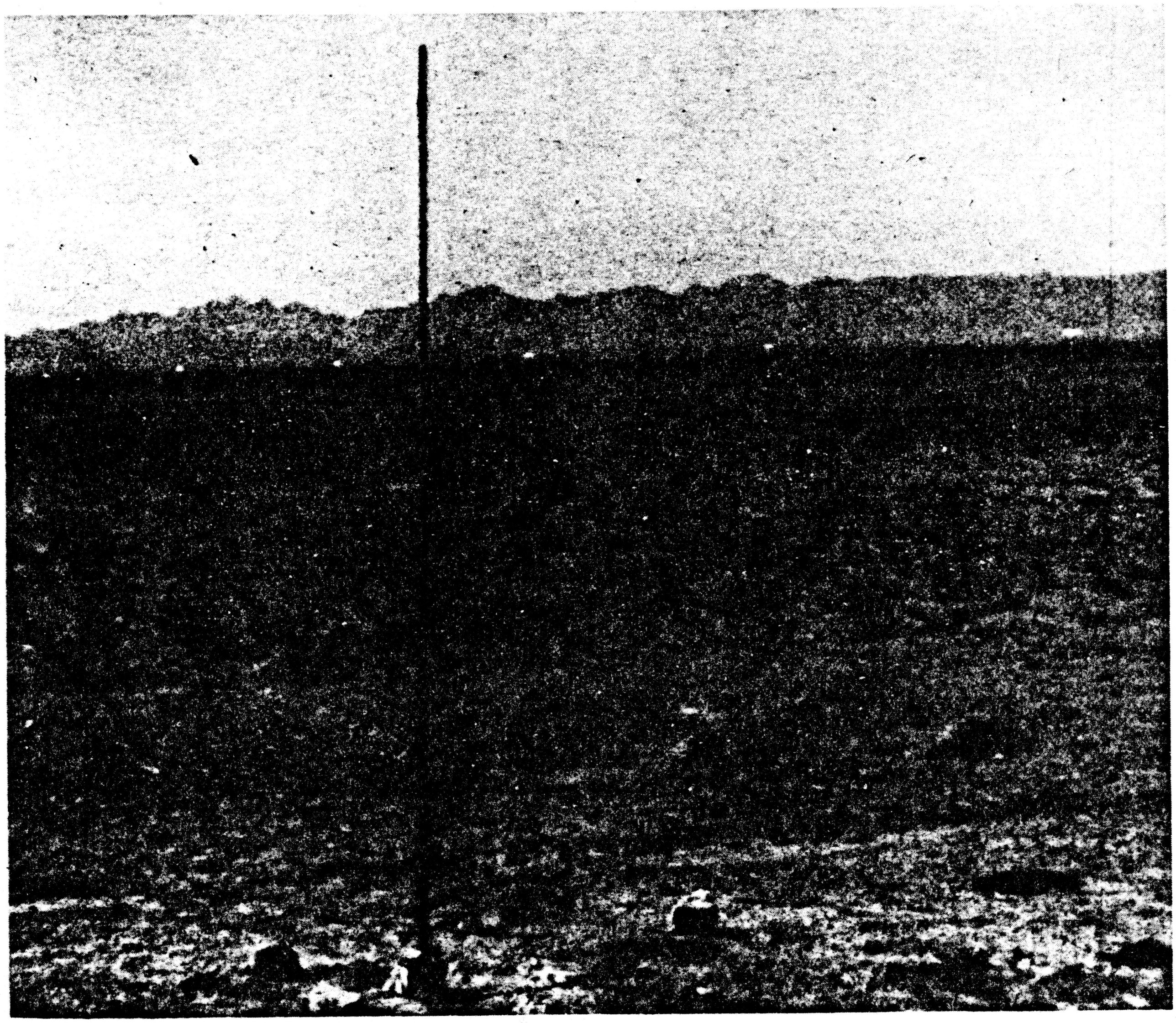


Figure 2. Gun-fired UEJ assembly.

general support

G-76/G Direct-Current Generator. The G-76 hand-cranked generator, developed under the sponsorship of PM-Army Tactical Communications Systems to power equipment used in the Special Forces Burst Communications System, is undergoing first-article acceptance sample testing at the production contractor, Simmond's Precision, Norwich, NY. It has been determined that, in addition to meeting the electrical power, combat ruggedness, and environmental requirements, the generator satisfies electromagnetic interference standards and is hardened to the effects of nuclear attack.

The Project Manager for Nuclear Munitions has determined that the generator will also serve as a source of power for the T-1333 permissive action link. Over 1,100 generators will soon be produced by Simmond's Precision for that application.

Logistical support of the G-76 was coordinated with the U.S. Army Communications Electronics Command, and the G-76 will be submitted for release to the troops in the first quarter of FY 82.

Miniature Hand-Cranked Generator. The miniature hand-cranked generator, the size of a pencil sharpener, contains a samarium cobalt rotor. Using this rare-earth material as the permanent magnet makes possible a generator design with high power density. The alternator is being designed to generate 25 W when the machine is hand cranked at 60 rpm. The crank speed is increased 100 times by a harmonic drive, so that at an input of 60 rpm the alternator rotor speed is about 6000 rpm. The electrical power from the alternator is rectified, stepped down in voltage by a dc-to-dc converter, regulated, and filtered to provide an output which will match fuze setter requirements. Because the amount of power required to operate a fuze setter is 5 W, approximately one turn of the crank handle is sufficient to set a fuze. Figure 1 shows the generator mounted for laboratory testing.

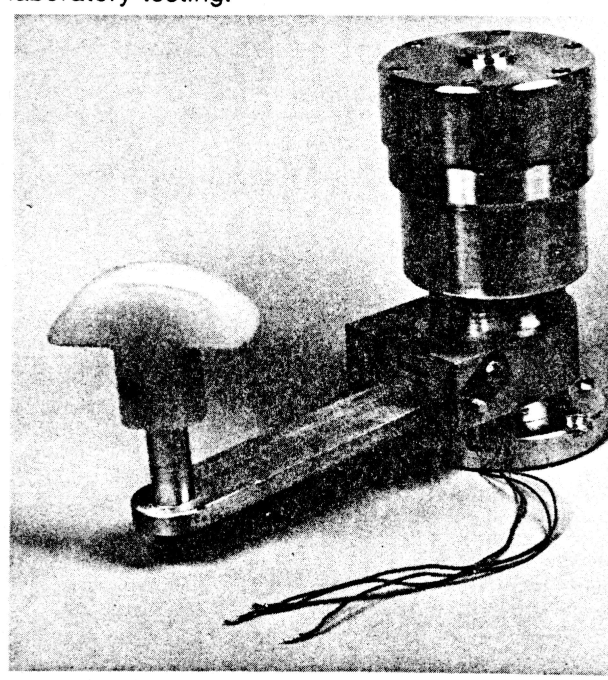


Figure 1. Miniature hand-cranked generator.

The use of a hand-cranked generator to power a fuze setter will eliminate the logistic and maintenance support needed when batteries are used. It will allow continuous availability of the setter in any combat situation or scenario. The generator is not adversely affected by temperature variations and, over an extended period of time, the generator could be less costly than batteries.

chapter 3. technical support activities

Civilian Personnel Office. The Civilian Personnel Office (CPO) is responsible for servicing personnel of HDL, ERADCOM Headquarters, BETA, USACC, and the Student Detachment Group (that is, interns involved with the Personnel Support Agency program). A full range of civilian personnel services are provided the serviced elements, with accomplishments and programs discussed below.

Personnel Summary. At the close of FY 81, the number of employees at HDL subject to the personnel ceiling was 1,079. Of this number, 49 were temporary or part-time employees. This compares with 1,145 total for FY 80, when there were 1,001 permanent and 144 temporary or part-time personnel.

Labor Relations. During the first two quarters of FY 81, three courses in labor relations were presented at HDL by the Labor Relations Training Center of the Office of Personnel Management. All merit pay employees were scheduled to attend at least one of the courses held. The course "Labor Relations for HDL Executives" provided a general overview of labor relations responsibilities for all management officials. Another course, "Labor Relations for HDL Supervisors and Managers," was provided for all merit pay supervisors. "Negotiating a Labor Agreement" was given to all laboratory and office chiefs who had bargaining unit employees in their organization. The purpose of the training was to ensure that all levels of management would become more aware of their labor relations responsibilities.

Negotiations were held during the third and fourth quarters of FY 81 with all three bargaining units concerning the implementation and impact of the General Performance Appraisal System on bargaining unit employees. In addition, the Commander appointed a management negotiation team in preparation for negotiations with the scientific and engineering bargaining unit at HDL. Ground rules were negotiated with the professional bargaining unit, and contract negotiations are expected to begin in early FY 82.

DA Merit Pay System. The first DA appraisal period for employees covered by the Merit Pay System was 1 October 1980 through 30 June 1981. A test of the appraisal system for all HDL merit pay employees was conducted in February 1981. An actual appraisal was completed for all HDL merit employees in July 1981, and the first payout under the merit pay system is due in October 1981. Approximately 175 employees will receive pay under the merit pay system.

High Grades. Because of the continued control over high-grade positions, GS-13 and above, the number of high grades at HDL has remained below the recognized ceiling of 256. At the close of FY 81 there were 231 high-grade employees at HDL compared to 237 in FY 80, and 236 in FY 79.

Engineer and Scientist Recruitment. Recruitment to fill engineering and science vacancies continues to be a high priority. All engineer and scientist applications for the positions GS-5 through GS-12 have been centralized to allow immediate referral of applicants. CPO coordinated recruitment visits by technical personnel, resulting in 77 interviews at 12 colleges and universities. Visits were scheduled at 21 colleges and universities for the first quarter

of FY 82. Recruiting for engineers and scientists at the GS-5 through GS-12 grade levels resulted in 66 selections during FY 81. Fifteen new employees entered on duty, including three minority members. In addition, two cooperative-education (co-op) students were converted to permanent employment; two former summer employees were entered on duty including one minority member; and one woman who had previously held a co-op and Schedule A appointment was converted to an engineering position.

Direct hire authority for all engineers GS-5 through GS-11 was granted to HDL by the Office of Personnel Management (OPM) on 22 April 1981. Eight engineers have been hired under this authority, including one minority engineer who was promoted before meeting time-in-grade requirements. A request was sent to OPM for approval of direct hire authority for GS-12 engineers. Two accelerated engineering training programs to promote entry-level engineers after six months are currently in draft form, and are being studied by the engineering staff at HDL.

HDL has implemented the Department of Army exception to CPR 950-1 which allows engineer and scientist vacancies for positions GS-13 and above to be filled through local merit promotion procedures.

Upward Mobility Program. The DARCOM Affirmative Action (EEO) Program Plan for FY 81 has the same goal for Upward Mobility positions as DA CPR 700. HDL exceeds the 1-percent goal, with a total percentage of 1.2-percent Upward Mobility positions, and Headquarters ERADCOM, serviced by the HDL CPO, exceeds the 1-percent goal with a total percentage of 2.5 percent. Of the 15 Upward Mobility positions identified for HDL, 13 are filled by women (3 black and 10 white), one is filled by a white male, and one position is under recruitment. Of the five Upward Mobility positions identified for Headquarters ERADCOM, three are filled by women (one black and two white) and two are under recruitment.

In an effort to increase management participation in the Upward Mobility Program, the area of consideration for program eligibility has been expanded to include temporary employees where there are no permanent applicants. HDL's Commander has vigorously supported the Upward Mobility Program; this support has been communicated to managers and the workforce.

Federal Equal Opportunity Recruitment Program (FEORP). DARCOM designated the Contract Specialist/Procurement Analyst (GS-1102), General Engineer (GS-801), Mechanical Engineer (GS-830), Computer Specialist (GS-334), Electronics Mechanic (WG-2604), and Heavy Mobile Equipment Mechanic (WG-5803) job series as targets for FEORP recruitment. Accordingly, HDL has expanded the applicant supply file to retain applications from women and minorities who meet the qualification requirements of these series. Meetings with representatives of minority groups were held to acquaint them with HDL as an employer, and mailing lists were expanded to include these groups. The HDL/ERADCOM FEORP plan, developed last year, is presently being updated to identify underrepresented series at this activity. In addition, the Applicant Supply System includes Veterans Readjustment Appointment eligibles, 30-percent disabled veterans, 10 point compensable disability preference veterans, former temporary employees, handicapped applicants, and applicants for positions for which HDL has recruiting authority. A Staffing Specialist and Equal Employment Opportunity Intern have been scheduled for the OPM FEORP training course during the first quarter of FY 82.

Volunteer Service Program. The volunteer program is in its second year. Five students began working in FY 81. In June, these five students were converted to salaried positions, four at HDL and one at the Navy. Nine new students were hired for FY 82, seven from Paint Branch High School, one from Bethesda-Chevy Chase High School, and one from Blair High School. The latter two students worked during the summer as participants in the American University Apprenticeship Program. This program is expected to attract young career-minded students to HDL as a permanent employer.

Career Management Program. Careerists continue to be responsive to individual notices as well as notices in the Weekly Bulletin and Personnel Info Sheets regarding the importance of initial registration and keeping registrations up to date. The process of updating all Career Program files continues.

Retirements. During FY 81 a total of 40 HDL employees retired (table 1). This is a 58-percent decrease from FY 80. The total of 40 retirements reflects a more stable situation and is in line with fiscal years 77 to 79. The retirement law has been changed to eliminate the look-back feature; this change makes it no longer advantageous for employees to retire just before the next cost-of-living increase.

Table 1. Retirements

FY	No. of retirees
1977	37
1978	42
1979	55
1980	95
1981	40

Staffing: Strength. In FY 81, the HDL civilian personnel strength subject to ceiling was 1,079 (including 49 temporary or part-time employees), a decrease from the FY 80 total of 1,145. Strength at ERADCOM Headquarters (Adelphi), serviced by the HDL CPO, rose from 183 in FY 80 to 205 in FY 81. Other groups served by the HDL CPO are not included in the calculation of personnel strength just given; these groups include 51 DARCOM Personnel Support Agency, 11 BETA, 9 U.S. Army Communication Command, and one employee not subject to the personnel ceiling. The decrease in the employment number at HDL between the fiscal years is attributed to several factors. On 31 July 1981 DARCOM placed a freeze on permanent hires through the remainder of the fiscal year. Subsequently, in September 1981, ERADCOM froze temporary hires through 30 September 1981. The presidential hiring freezes earlier in 1981 also reduced the hiring rate.

Cooperative Education Program. During FY 81, 23 co-op students were hired from Drexel University, Howard University, Maryland University, North Carolina State University, and Virginia Polytechnic Institute and State University. Eight co-op students left the program as undergraduates. Six students graduated; of those, two were converted to permanent employment. At the end of the fiscal year, 10 students were in a duty status and 31 were on leave without pay while attending school. Of the 41 current co-ops, two are women (both Asian-Pacific) and four are minority men (two Asian-Pacific, one black, and one Hispanic). A physically handicapped student is also part of the co-op program.

Student Trainees. Fifteen undergraduates in engineering and science were hired this year, and six prior year undergraduates returned. Of the 21 student trainees working for this summer, two were women and one a male minority member.

Summer Employment Program. This program (which does not include those employed in the Student Trainee and Federal Junior Fellowship Programs) provided work opportunities for 87 high school students, college students, and a faculty member, affording them gainful employment while enabling them to use their academic skills and knowledge. Of these 87 employees, 43 returned from the previous summer.

Vocational Office Training Program. Of the 30 high school seniors in the program for the 1980-1981 school year, 26 were employed at HDL after graduation (25 summer appointments and one temporary one-year appointment) and four chose to resign. As of the end of the fiscal year, 12 summer employees were converted to temporary one-year appointments, and three were converted to permanent appointments. For the 1981-1982 school year, 32 students were hired from eight area high schools.

Clerical Recruiting. There were approximately 188 applications in the applicant supply file for clerical vacancies at the end of the fiscal year. During FY 81, 47 permanent and 36 temporary clerical positions were filled.

Research and Engineering Apprenticeship Program. This work-study program for high school students pursuing basic education in science and engineering is currently being explored at HDL. Appropriate organizations have been queried as to interest, nomination of sponsors, and identification of job assignments.

DARCOM Career Intern Program (PSA-74-1). Of the 13 highly qualified candidates referred to Headquarters DARCOM in FY 81, one from Ft. Detrick was selected as an "alternate" under the Civilian Personnel Administration Career Program, and one

from Ft. Meade was selected for the Procurement Career Program. In addition, an HDL employee, referred to HQ DARCOM during the first quarter of FY 82, was selected for the Procurement Career Program but declined the offer (being unable to move at this time).

Federal Junior Fellowship Program. The Federal Junior Fellowship program continues to be very productive. At present, HDL employs 24 Federal Junior Fellows (10 minorities—5 females and 5 males). Of the 11 new students recruited in mid-FY 81, 5 are on duty and 6 will begin during the fall semester break.

Average Grade Calculation. The average grade of HDL employees at the end of the last three fiscal years is shown in table 2. Full-time permanent/temporary strength decreased by 66 employees during FY 81, bringing the total to 1,079.

Table 2. Average Grade Calculation

Category	30 Sept 79	30 Sept 80	30 Sept 81
Full-time permanent	10.1411	10.2045	9.9481
Full-time permanent, temporary	9.9704	9.9144	9.8487

Training. The FY 81 training program was designed to address specific functional competencies as well as to develop other behavioral skills needed to accomplish the organization's mission. The emphasis was on on-site training wherever practicable. To offset the problems of increased costs (tuition, travel, per diem expenses) and reduced slot allocations, 41 on-site courses were conducted at this activity. This represents an increase of 12 courses above the FY 80 total. The total number of participants in the entire program was 1,036 in FY 80, and 1,175 during FY 81.

Despite the increase in the number of courses conducted on site during FY 81, the cost of training continues to escalate. An additional $25,000 was allocated to the training budget during the third quarter to accommodate these needs. FY 81 training activity is summarized in table 3.

Table 3. Training Activity

Total trained	FY 80	FY 81
External training	587	588
On-site training	449	587
Total	*1036*	*1175*
Special programs		
DARCOM interns	26	24
Upward mobility	12	20
MARED	8	5
Local interns	9	12
Apprentice	1	—
Long-term training	—	1
Part-time fellowships	1	2
On-site courses		
Automatic data processing	17	15
Scientific and engineering	7	7
Administrative	4	6
Management	—	11
Procurement	—	2
Total	*28*	*41*

Management Information System (MIS) Office. The MIS office operates a modern, large-scale computer center and provides complete automatic data processing (ADP) services to HDL and tenant activities involving both scientific and administrative computing applications.

Administrative System Support. Administrative system development concentrated on maintenance and improvement of existing data bases in FY 81. Difficulties in securing contractual development support hindered new development. Nevertheless much has been achieved.

Locally developed, new applications implemented include the following:

- General Ledger—a data-base system for processing general accounting data for the Finance and Accounting Office (F&AO).

- Budget 1088 system—a data-base system for analysis, review, and automated reporting of historical payroll data.

• RHA Locator—a data base for management and control of documents stored in the Records Holding Area.

• Manpower Planning—a system under development for the Plans and Operations Office.

• SWL financial management systems—modified versions of the HDL financial accounting systems, implemented for the support of HDL F&AO service to the Signals Warfare Laboratory (SWL).

Several new applications have also been implemented or enhanced for HQ ERADCOM.

New standard systems installed were

• Electronic Warfare Integrated Reprogramming (EWIR) and

• Technical Data/Configuration Management System (TD/CMS).

Upgrading of interactive data-base access and data-entry front ends has continued. Major improvements have been implemented for the contracts and small purchases systems. The cost accounting section has an interactive data-entry front end with full edit capability for the first time.

Integration of the financial management database system continued this year. F&AO voucher examinations payments data have now been combined into the Procurement Office small purchase data base. A similar link is being designed to the contracts data base, with implementation scheduled for early FY 82.

The MIS office is currently preparing a program to automate the document accountability system, which should facilitate input, maintenance, and control of the document accountability system. Preliminary implementation of the automated system will occur during the early part of 1982.

Another significant development effort underway is the application of bar-coding techniques for conducting the inventory of accountable property. This feature is being implemented for the Installation Equipment Management (IEM) standard Army system but requires local bridging software.

Computer Center Support. This year the computer was augmented with an IBM 370/168 attached processor (AP), and a new operating system, MVS SP1, was put into production. The central computing complex now consists of an IBM 370/168 AP with 8 megabytes of main storage, 9 channels, 72 disk drives providing over 11 billion bytes of on-line disk storage, 12 tape drives, and over 130 communications lines. This complex supports over 1,200 registered users and processes over 1,000 time-sharing sessions and 1,100 batch jobs each day.

Planning and procurement of a second large-scale computer, an IBM 370/168 MP, were completed. On September 30 installation was in progress. This new computer doubles the processing capacity at the computer center.

Other achievements include the following:

• The computer access and data security package ACF-2 was installed and tested. It is in production, controlling access to the computer system. Planning is in process for phasing in the control of access to user data.

• The Programming Assistance Group (PAG) provided analysis and programming support to the S&E areas as well as to the general user community. PAG taught 19 computer courses and published a monthly newsletter.

• A four-color drum plotter, CalComp 1051, and the software to generate plots were installed.

• The interactive graphics packages of DISSPLA and TEL-A-GRAF were installed. They were integrated with S2KPLOT, a set of programs designed to retrieve and plot information from System 2000 data bases.

• A pre- and post-processor called MENTAT was obtained for plotting NASTRAN data.

• FORTRAN 77 was installed.

- The SPEAR network was improved. SPEAR is a distributed intelligence computing network with three PR1ME 400 minicomputers as its main processors; a fiber-optic network throughout the main complex was completed, and the fiber-optic multiplexers are fully operational. The links between the PR1ME computers and the IBM computer were expanded and are now operational.

Technical Information and Administrative Office. Communication of scientific and technical information is one of the most important aspects of research, development, testing, and evaluation; communication leads to widespread use and ultimate benefits of research. However, this process becomes increasingly difficult and complex as scientific and technical knowledge grows and as the need for multidisciplinary efforts increases, especially in sophisticated weapons systems. The amount and quality of scientific and technical information have grown steadily through the sixties and seventies.

Technical Information Branch. The Technical Information Branch acquires, organizes, and disseminates technical and scientific information appropriate to the support of HDL and ERADCOM Headquarters projects.

During FY 81, the library circulated approximately 13,000 books, journals, and technical reports and provided 30,432 reference items. The DIALOG, SDC, and DTIC on-line computerized systems for information retrieval continue to be the most important and popular reference tools available. These sources of information include Physics Abstracts, Electrical and Electronics Abstracts, Chemical Abstracts, Citation Index, Engineering Index, Library of Congress Catalog, Work Unit Information on DoD Research Projects, and Independent Research and Developments.

Technical Reports Branch. The Technical Reports Branch prepares all the formal scientific and technical reports that are disseminated externally by HDL and ERADCOM Headquarters. This branch strongly supports the unique function of these laboratories in support of the Army—in research and development and in the field. Technical Reports Branch staff members do the editorial review and prepare the camera-ready copy for seven types of formal reports, as well as for the special handbooks, brochures, and preprints that are disseminated externally by these laboratories. Also, they editorially review proceedings papers, journal articles, contractors' reports, memoranda of directives, and other special documents. In FY 81, the Technical Reports Branch processed 354 reports, a total of 13,744 manuscript pages.

The writer-editors are available to assist authors in the planning, organization, and writing of reports. Also, each report receives the personal attention of a writer-editor through the production cycle—from the editorial review through camera-ready preparation, proofreading, and final approval for publication. As part of their effort to assist the authors, the writer-editors conduct periodic writing seminars; the last seminar, which was conducted in July 1981, was intended primarily to help employees in the summer student technical program to write their reports for publication, as well as to present their reports orally at the Student Symposium.

The editorial assistants of the branch compose, design, and lay out the camera-ready copy for formal reports, as well as for special publications. Also, these assistants share their expertise on the best ways to record complex technical material on word-processing and photocomposition equipment. They have conducted personal training sessions and published manuals on preparing technical material for publication.

Visual Information Branch. The Visual Information Branch is responsible for the coordination and production of all audiovisual material used by HDL and tenant activities at Adelphi. Included are displays, exhibits, illustrations for material and external reports, and artwork for conference presentations. During FY 81 the branch processed 3,580 work requests for audiovisual services. This figure is an increase of 6 percent over the previous year. Of these work orders, 1,355 were for photography work; 742 were performed in house, and 613 on contract. The remaining 2,225 work orders were for graphics work, of which 1,002 were performed in house, and 1,223 on contract. In addition, scheduling, operation, and maintenance of audiovisual equipment associated with the HDL auditorium are responsibilities of this branch.

Printing and Reprographics Branch. The Printing and Reprographics Branch is responsible for providing printing, duplicating, and binding services to HDL and tenant activities. The number of items (bound volumes, technical reports, and manuals) printed in-house and on contract are as follows:

In-house impressions	7,999,531
Contracted items	34,416
Contracted impressions	1,649,466

A test key control system program was implemented on all self-service copy machines. It is estimated that the program will reduce the copy volume by 25 percent, thereby saving $19,700 annually. The frequency of machine downtime is also expected to be reduced. Records are being maintained to document the results. If not sufficiently cost effective, this program will be terminated at the end of the second quarter of FY 82.

This branch was also instrumental in coordinating and printing the Open House Brochure for the open house held in October 1980; the branch also processed many priority documents for high-level conferences, many of which require very short turn-around times.

Administrative Services Branch. The Administrative Services Branch has increased training in records management, from the creation of records, through daily office maintenance of records, to the final disposition.

The branch strives to minimize the use of local forms and publications, and to substitute Army regulations and higher headquarters supplements. The result of these efforts should reduce paperwork at HDL.

A new record-disposal schedule for laboratory notebooks, initiated by this office through DA Headquarters, authorized the early retirement of 1,150 laboratory notebooks from this installation.

The improved automation of the record-holding area files has resulted in more efficient scheduling, receipt, and disposal of installation records.

In an effort to reduce Army mail costs, HDL was directed to use postage metering equipment and USPS Express Mail. The HDL facility processes over 175,000 pieces of mail per week, and normal costs for outgoing mail are approximately $2,500 per week. HDL's mail section was recognized by William H. Schneider, Chief of Staff of DARCOM, and by ERADCOM's Commanding General, for a successful test using Express Mail between the HDL facility and Ft. Monmouth, with an average monthly savings of over $300.

In FY 81, classified Document Control Center personnel inventoried and reconciled all secret documents (approximately 30,000) with all 75 administrative accounts. This resulted in the destruction or downgrading of 12,000 documents, of which 5,000 were library holdings. Concurrently, procedures were reviewed and, where possible, automated in an effort to strengthen the document control system.

Procurement. The HDL Contracting Office supports, as its direct mission, HDL and the Signals Warfare Laboratories. Under intraservice support agreement, the office provides procurement services as required under AR 5-5 for study contracts. Users include TRADOC, FSTC, Headquarters ERADCOM, and other agencies and activities as directed by Headquarters DARCOM or Headquarters ERADCOM. Table 4 and figure 1 show the total contract dollars and number of actions awarded in FY 81, both as the direct mission and the indirect mission support. Table 5 shows the total contracts awarded in FY 81.

Significant contract actions for FY 81 include the awarding of contracts, on a sole-source basis, for the Communications High Accuracy Airborne Location System for Guardrail to IBM for $4.5M, and an award to GTE for the M548 vehicle

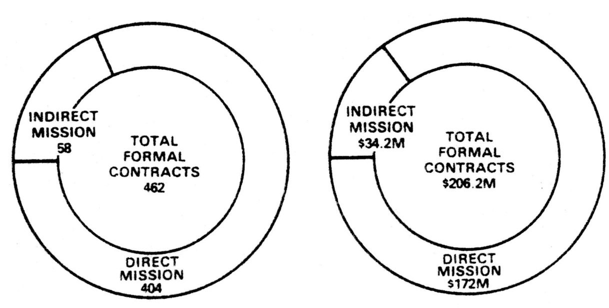


Figure 1. Direct and indirect mission support.

Table 4. Direct and Indirect Mission Support, FY 81

Type of support	Agency	Dollars
Direct	HDL	84,078,226
	SWL	87,924,526
Total direct mission		*172,002,752*
Indirect	ASAS	19,471,331
	BETA	8,169,450
	CAC	1,295,980
	DARCOM	627,741
	CM-CCM	47,968
	ERADCOM	569,438
	Ft. Monmouth	99,865
	FSTC	1,919,471
	IMDSO	1,335,363
	OTEA	343,503
	TRADOC	251,802
	Other	20,959
Total indirect mission		*34,152,871*
Grand total (direct and indirect)		**206,155,623**

Table 5. Contracts Awarded in FY 81

Types of contracts	Quantity	Dollars
Actions		
Over 10K	462	200,090,810
Under 10K	8,440	6,064,813
Sole Source		
Over 10K	352	174,384,773
Under 10K	7,432	4,489,819
Competitive		
Over 10K	110	25,706,037
Under 10K	1,008	1,574,994
Nonprofit		
Over 10K	15	1,323,708
Under 10K	365	188,040
Large business		
Over 10K	347	190,367,391
Under 10K	2,037	2,538,000
Small business		
Over 10K	100	7,799,711
Under 10K	6,038	3,338,773
8(a)		
Over 10K	5	304,433
Under 10K	0	—

modification kit for TACJAM for $4.5M. In addition, GTE received an award of $3.3M ($2.8M was supplemental money) for GFE (government-furnished equipment) for the Trailblazer program. Trailblazer is a division tactical ground-based automated position-finding and intercept system with ESL, Inc., as the prime contractor. ESL received a total of $36.5M (supplemental money received in August FY 81) for modifications to the Trailblazer system.

A reorganization within the Contracting Office (Adelphi) has resulted in the establishment of the Procurement Operations Branch, which includes Price Analysts, Procurement Analysts, an Industrial Property Specialist, and a Procurement Clerk, headed by a GS-13 chief. The function of the office is to improve the overall quality of solicitations and contracts through review, regulation and directive interpretation, and policy guidance and cost/price support to the purchasing branches. DARCOM provided the office 12 Near-Term Army Readiness Slots, of which 4 went into the new branch; the remaining 8 slots went to the purchasing branches.

During FY 81, following the DoD procedures for contracting regarding Commercial Activities (formerly Commercial or Industrial-Type Activities—CITA), solicitations were issued for custodial services and guard services, with the intent of determining whether those services would be less costly if contracted out. The government prepared an in-house cost-to-perform estimate, and in both cases the government estimate was determined to be lower. The government estimate for the guard services (three-year contract) was $358,267 lower and for the custodial services (three-year contract) was $897,078 lower. By retaining performance in-house rather than contracting out, the government is saving an estimated $1,255,345.

Office of Legal Counsel. The Office of Legal Counsel provides legal advice and services to the Commander and his staff in the fields of acquisition, intellectual property, and all other business

and commercial law matters arising in the administration of HDL. Legal support of all aspects of appropriated fund acquisition is provided from inception of requirements through the solicitation, award, administration, and close-out of contracts. The office coordinates protests against awards filed with the General Accounting Office, higher commands, and the contracting officer, and processes appeals by contractors to the Armed Services Board of Contract Appeals against final determinations of contracting officers.

Legal counsel and services provided in nonacquisition-related matters include areas such as civilian personnel actions, labor relations, employee standards of conduct, security requirements, release of information, claims by and against the United States, congressional inquiries, real and personal property actions, external audits, environmental law, intra/interservice support, nonappropriated fund activities, and litigation, hearings, or investigations involving matters arising in the administration of HDL. In matters involving intellectual property, the office evaluates, reviews, and screens potential contractor inventions; maintains contract follow-up on patent provisions; investigates patent infringement claims; counsels operating personnel on patent rights, technical data, copyrights, and other proprietary rights; evaluates employee invention disclosures; and prepares and prosecutes applications for patents in conformity with U.S. Trademark and Patents Office Policy.

In FY 81 legal services were provided for HDL and organizations supported by HDL, including DARCOM Headquarters, ERADCOM Headquarters, TRADOC, FSTC, the BETA Project Office, TECOM, and the Study Management Office, ASA.

During the year, the office completed approximately 715 formal reviews of acquisition actions, and handled approximately 330 general or administrative law problems. In addition, a significant amount of professional time was spent in contract board actions and meetings, and in providing legal counsel and services in response to informal requests for assistance. Patent counsel received 41 employee invention disclosures and prepared and filed 24 applications with the Patent Office. During FY 81, 28 patents were issued to HDL inventors, the applications for some of which were filed in previous fiscal years.

Resources Management Review and Analysis Office. The Resources Management Review and Analysis Office is responsible for providing the Commander with an independent analysis of resource allocation and use. During FY 81 the office was primarily concerned with effecting the Commercial Activities (CA) program; in this regard, it conducted four cost studies and four management studies and prepared four statements of work; the result was a manpower authorization increase of approximately 34 spaces. The office also conducted 16 cost studies primarily in support of R&D projects, resulting in a projected cost avoidance of approximately $10M. In addition, the office effected 3 reorganizations, initiated and/or reviewed 22 inter/intraservice support agreements, prepared 4 command briefings, and maintained the laboratories manpower program.

Commercial Activities Reviews. During FY 81 HDL completed CA reviews on the custodial, guard, and roads/grounds functions, and initiated CA reviews on the facilities, supply, mail, transportation, reproduction, and motor pool functions. Completed reviews resulted in all functions remaining in-house and HDL receiving 34 additional manpower spaces for the custodial and guard functions (a request for 3 additional manpower spaces for the roads/grounds functions is still pending DA approval). Initiated reviews resulted in the exemption of the mail and reproduction functions and the completion of draft management studies and statements of work for the remaining functions. At present these reviews affect some 12 functions and 54 manpower spaces, and are scheduled for completion in FY 83.

Reorganizations. In November 1980, the Logistics Management Office was reorganized as a result of a Command Equipment Management Program Review (CEMPR) and Command Supply Discipline Program (CSDP) review. The reorganization included (1) the establishment of the Property Book Accountability Section within the Equipment Management Branch and (2) the consolidation of the former Supply Management and Issue Branch and the Materiel Acquisition and Disposal Branch into a single branch, the Supply Support Branch. In September 1981, the Buildings, Grounds and Utility Branch of the Facilities Engineering Office was abolished and two new organizational elements established. The newly established elements were

designated the "Environmental/Energy Conservation Branch" and "Blossom Point/Woodbridge Maintenance Shop." The reorganization was effected because of increased requirements in environmental and energy conservation and DA's accession of the Blossom Point Test Facility.

Logistics Management Office. The Logistics Management Office was reorganized with an augmented staff, to increase the office's capability to adequately perform the logistics mission and functions.

- A Property Book Management Section was added to the Equipment Management Branch. This section will coordinate the management of the 146 individual hand receipts which account for HDL's installation equipment.

- The Supply Management and Issue Branch merged with the Materiel Acquisition and Disposal Branch to create a new Supply Support Branch. This action resulted in better intrabranch communication and control, more effective use of resources, and improved efficiency through simplified document flow.

The first-stage implementation of a Bar-Code Inventory System (BARCIS) was completed with the application of bar-code labels to the 37,000 equipment items accounted for in the 1981 installation property inventory. This system, when operational, could reduce the man hours required to inventory property by more than 70 percent compared with the previous inventory method.

The property card system of property book accounting for hand-receipt holders was replaced with a single-signature hand-receipt listing. This new listing eliminates the need for hand-receipt holders to sign and maintain hundreds of individual property cards, simplifies the process of changing individual hand-receipt records, establishes a capability for frequent or as-needed update of individual hand receipts, and thus improves the probability that property book records are accurate.

Mobility fuel consumed was reduced by 57 percent. These energy-consumption reductions were a direct result of intensively managing administrative-use vehicles. The motor pool organization planned ride sharing (wherever practical) and allowed for the use of private vehicles in performance of local travel to conduct official business where this is advantageous to the government. Local transportation coordinators were identified, and desk procedures, routines, and registers were established to facilitate validation and control of all local travel.

The reliability of the TMDE Calibration Program Management data base was improved, with the result that the system was recently described by the Command Calibration Coordinator as having been implemented in "a most adequate fashion." The HDL program for notifying TMDE users when equipment is found to be out of tolerance was considered by the Command Coordinator to be outstanding.

A value engineering project was initiated to retrofit the automated storage and retrieval system in the supply warehouse. When complete, this project will increase the retrieval speed of the equipment by more than 20 percent and the retrieval reliability by 50 percent. Additionally, the equipment life will be extended for four to five years beyond the date of retrofit.

Facilities Engineering Office. The Facilities Engineering (FE) Office is responsible for the management of all HDL real property and for providing laboratory engineering support services. The FE Office establishes programs for Military Construction Army (MCA), master planning, space utilization, and real property inventory. Because of the new emphasis on energy, environment, and hazardous and toxic materials, the Environmental/Energy Conservation Branch was established to develop new programs in these areas, including ECIP (Energy Conservation Investment Program), the DEIS (Defense Energy Information System) program, NEPA (National Environmental Protection Act) programs, wildlife management, and environmental impact assessments. Responsibility for maintenance and repair (MR) for buildings, grounds, and utility systems covers a full range of mechanical, electrical, civil, and architectural disciplines. Also included are entomological and custodial services and maintenance of fire-prevention and intrusion-detection systems. Services are provided at three installations: Adelphi,

Blossom Point Field Test Site, and Woodbridge Research Facility. Various MR and engineering services are supported by contract as the need arises. These services are also provided for ERADCOM Headquarters, BETA, and other tenant organizations.

Maintenance and Repair. The HDL FE Office's MR activities and expenditures of resources are primarily through the performance of Individual Job Orders (IJO's), Standard Operating Orders (SOO's), and Service Orders (SO's). (These activities are reflected by quarter in table 6.) The IJO's and SO's are generally in direct support of real property maintenance and repair activities and the technical programs of the laboratory, whereas routine services (custodial) are performed through the SOO's.

MCA Program. The MCA Project Summary is formulated during October at the Installation Planning Board meeting and proposed new projects are submitted to DARCOM for approval. This summary includes current approved projects as well as short-, intermediate-, and long-range projects. Examples of current projects are the completion of a new energy control and monitoring system, and modifications to the heating-cooling plant, both funded under ECIP. Proposed projects at Adelphi include an addition to the FE Office within existing building space, an addition of a new sixth floor to the administration building, and the addition of another floor to the Research and Engineering Building, to house the computer center. A Command and Control Building II and a visitor's center are being proposed for the Woodbridge Research Facility.

Master Planning. The Adelphi updated Master Plan has been submitted for approval. Blossom Point's Master Plan (its first) is scheduled for submission in FY 82. The Woodbridge updated Master Plan was submitted in FY 81.

Environmental and Energy Management. The Environmental and Energy Management Programs are accomplished by the recently reorganized HDL Environmental/Energy Conservation Branch within the FE Office.

Environmental Impact Assessment. The Environmental/Energy Conservation Branch prepares an annual Installation Environmental Impact Assessment (IEIA) and project EIA's in support of the MCA program during the fiscal year. This office provided guidance to various HDL staff for the preparation of mission and mission-support EIA's and provided staffing for HDL EIA's for final approval by the HDL Commander.

Environmental Pollution Control. The Environmental/Energy Conservation Branch is responsible for monitoring and reporting air-, water-, and noise-pollution control techniques and violations. HDL is considered to be a minor air-pollution source by EPA criteria, and is in compliance with all air-quality regulations. HDL is also in compliance with current water-pollution control regulations. HDL has no major continuous noise sources and

Table 6. FY 81 Work Orders Completed

Work orders[a]	First quarter		Second quarter		Third quarter		Fourth quarter		Total FY 81	
	No.	MH	No.	MH	No.	MH	No.	MH	No.	MH
IJO's	161	15,998	127	14,145	134	15,358	155	15,703	577	61,204
SOO's	88	39,147	90	40,347	90	40,347	88	39,147	356	158,988
SO's	1,043	4,258	989	4,225	906	3,707	894	4,063	3,832	16,253
Total	1,292	59,403	1,206	58,717	1,130	59,412	1,137	58,913	4,765	236,445

[a]IJO = Individual Job Order
SOO = Standard Operating Order
SO = Service Order
MH = Man Hours

therefore is in compliance with noise-pollution regulations.

Radiation Pollution Control. All electronic sources of ionizing radiation at HDL are in compliance with the protective measures specified by the Occupational Safety and Health Administration (OSHA) and current U.S. Army regulations. All radioactive materials possessed by HDL are used in accordance with the protective measures specified in the U.S. Nuclear Regulatory Commission licenses which apply to them.

Solid Waste Management. A comprehensive waste-paper recycling program for Adelphi and Woodbridge was implemented during 1979. The program was expected to generate approximately $5,000 a year in revenue sales for HDL. Actual income has been less than predicted.

Toxic and Hazardous Materials Management. HDL does not handle significant quantities of toxic materials, except for pesticides for its insect/pest-management program and petroleum fuels for general heating operations; these substances are used in accordance with federal and Army regulations. A Hazardous Substance Spill Control and Contingency Plan and an Installation Spill Contingency Plan have been prepared for all HDL sites. These plans provide procedures and programs for the management of hazardous materials and controls for potential spill incidents.

Land Management and Conservation. The various flora and fauna on HDL sites are maintained and protected through several active conservation programs developed by the Environmental Coordinator's Office.

A Natural Resources Fish and Wildlife Management Program has been initiated in conjunction with resource conservation activities at HDL. Fish, waterfowl, deer, and small mammals found in the woodland areas on the Woodbridge and Blossom Point sites are provided with appropriate food and shelter through this program.

In keeping with DA policy to comply with legislation directed at preserving our cultural resources, the Blossom Point site was the subject of a cultural resources survey in 1980. The purpose of this survey was to investigate the extensive shell middens, artifacts, and burial sites at Blossom Point. The survey also included investigations of prehistoric land use, protohistoric Indian land use, and land use by Euro-American and minority groups during the last 350 years. The survey will provide background data for future land management plans and environmental documents. The final report was submitted in September 1980.

Energy Conservation. HDL is making progress in energy conservation efforts and new programs are being developed and implemented. Another ECIP contract has been awarded, and five new ECIP projects have been prepared for submittal to the MCA program. The Energy Advisory Group is meeting monthly. Contingency plans for electricity, heating fuel, and mobility fuel have been prepared to maximize conservation at HDL.

Energy and Environmental Training. Personnel in the Environmental/Energy Conservation Branch and appropriate FE staff have attended several federal, Army, and DARCOM conferences and workshops for Environmental Management and Energy Conservation in an effort to continue expanding personnel knowledge and capabilities.

Security Office. In fulfillment of its missions and functions, the Security Office continued to upgrade the security awareness of HDL personnel. Members of the Defense Industrial Security Institute presented a briefing to all personnel on "The Hostile Threat to the Research and Development Community." General security education training was provided by members of the Security Office to all personnel, highlighting the need to eliminate security violations. The security education program was expanded to include specialized training for managers, project officers, and clerical personnel.

Implementation of the Army's information security program was enhanced by the publication of local procedures and policies. An inspection program was initiated for organizations which maintain classified material. The program was designed to identify problem areas in the handling of classified material and assist in solving them. Twenty-eight organizations were inspected, which

resulted in a substantial improvement in HDL's information security program. The total number of security violations at HDL decreased from 8 in FY 80 to 5 in FY 81.

A CA survey was conducted which determined that the security guard function should remain inhouse. An authorized strength of 43 guard force personnel was approved, and actions were taken to recruit and select eligible guard force candidates to fill vacancies which resulted from the CA survey. A new guard force training program was instituted to upgrade the quality of security protection provided to HDL.

Safety Office. The Safety Office is responsible for assuring that employees are provided a safe and healthful work environment through implementation of Army regulations, OSHA standards, and commonly accepted safe work practices. The office provides advice and services to management and employees in such areas as industrial, chemical, explosives, motor vehicle, and both ionizing and nonionizing radiation safety.

Day-to-day safety performance was monitored by continuous safety surveys performed throughout the installation. During the year, 148 such surveys were conducted, which led to the identification of 134 conditions in violation of safety and health standards. To date, 116 of these conditions have been corrected, with action pending on the remainder. To prevent employees from being exposed to harmful substances, the office performed workplace environmental monitoring at areas or operations where the materials being used might cause potentially hazardous atmospheres. Although monitoring during the past year consisted of sampling at various times for such contaminants as asbestos, carbon monoxide, sulfur dioxide, ozone, acetic acid, and diisocyanates, no harmful concentrations or employee exposures were discovered. In addition, a comprehensive survey of operations involving noise was conducted. Where sound-level measurements indicated noise levels above 85 dB/A, signposts were installed describing the requirement for hearing protection. The office determined that all people working at noise-hazardous operations were receiving periodic audiograms and had been issued the required protection. Where possible, engineering controls were adopted to reduce noise levels below the hazardous level. During this period, a hearing conservation program survey rated HDL excellent in protecting employees against injurious noise levels. This survey was conducted by the Army Environmental Hygiene Agency (AEHA).

The Radiation Protection Officer (RPO) or his alternate conducted safety surveys at operations involving ionizing and nonionizing radiation-producing devices. Monthly film badge service was provided, and leak tests of radioisotopes and x-ray machines were performed quarterly. Five Nuclear Regulatory Commission (NRC) licenses and two DA permits authorizing the use of radioisotopes were kept current. During the year, the RPO met frequently with the Radiation Control Committee, a group of knowledgeable employees in the fields of ionizing and nonionizing radiation, to review operations and resolve problems involving radiation protection. During the year all ionizing radiation workers received either initial or refresher training in radiation protection and facility operation. Program surveys by the AEHA concerning nonionizing radiation and by NRC concerning ionizing radiation found HDL to be in compliance with Army and NRC regulations regarding those operations.

In FY 81, the office reported to higher headquarters the occurrence of 3 Army motor vehicle accidents involving property damage only and 11 additional industrial-type accidents which resulted in personal injury.

Small and Disadvantaged Business Utilization (SADBU) Program. Total business awards of HDL, SWL, and the PM for the All Source Analysis System (ASAS) were $196,235,860, with small business awards of $11,906,322 (6 percent). Total small business set-aside awards were $2,268,549. There were 6 awards by HDL amounting to $742,583 under the Small Business Administration (SBA) section 8(a) program, where awards are made to socially and economically disadvantaged small firms on a noncompetitive basis, with SBA as the prime contractor and the small disadvantaged concern the subcontractor. In direct awards to small disadvantaged firms through normal competitive procedures, with no preferential treatment involved, HDL made 187 awards totaling $479,564.

There were no FY 81 goals assigned to HDL, SWL, or PM-ASAS in the SADBU program area.

HDL awarded $81,188,691 during FY 81 in business awards, of which $5,153,639 (6 percent) was awarded to small business concerns. The HDL Contracting Activity at Vint Hill Farms Station, Warrenton, VA, is responsible for SWL and PM-ASAS awards. This year SWL made $87,719,151 in contract awards over $10,000, with $1,463,271, or 2 percent, to small business; PM-ASAS made $22,478,177 in contract awards over $10,000, with $2,192,872, or 10 percent, to small concerns.

Comparison of FY 81 and FY 80 performance reveals the following: in FY 81 total business awards were $196,235,860 versus $194,050,906 in FY 80; small business awards were $11,906,322 versus $10,972,547 in FY 80 (the percentage of small business dollar awards was 6 percent in both FY 81 and FY 80). In business actions, there were 7,785 in FY 81 and 7,537 in FY 80, with small business firms receiving 5,829 awards in FY 81 and 5,811 in FY 80 (percentage awards of 75 percent in FY 81 and 69 percent in FY 80).

Community Assistance Office. The Community Assistance Office (CAO), which holds responsibility for intervention with alcohol and other drug problems throughout HDL, has expanded the scope of its services to cover a wide range of personal issues which adversely affect HDL's productivity. Located in a new office, easily accessible to employees and their families, the CAO is building momentum for meeting the diverse needs of ERADCOM's largest workforce.

FY 81 efforts reflected a significant increase in program use involving clinical services for approximately 3.1 percent of the HDL workforce. The CAO also afforded HDL management the opportunity to participate in a preventive seminar on managing stress conducted by the Psychiatric Institute of Washington. Many of HDL's general workforce attended a presentation by Don Newcombe, former Brooklyn Dodger, regarding his dramatic recovery from alcoholism, a disease which, by itself, presents one of the greatest single barriers to the productivity and well-being of any organization.

In an effort to reduce prevailing misconceptions about program mission and function, the CAO has opened its doors to the HDL workforce through a series of on-going briefings designed to explore attitudes and educate interested employees about program services. In-house support groups are also being developed to assist employees who mutually define goals for minimizing problems which adversely affect daily living.

Equal Employment Opportunity (EEO) Office. There have been positive results in the EEO Program during FY 81. Although progress in all areas has not reached the desired level, a continuation of current trends in management support and resource allocation should allow such progress to be realized in the near future.

During FY 81, the ERADCOM/HDL Equal Employment Opportunity Advisory Council was established. This council will provide advice to the CG, ERADCOM, the Commander of HDL, and Commanders of any tenant organizations at Adelphi, MD, regarding Equal Employment Opportunity or Equal Opportunity Programs. Some of the areas in which the council has expressed particular interest are upward mobility, merit promotion, and training opportunities.

Program emphasis on the recruitment of women and minorities into the E&S career field is a continuing requirement. Participation in the Armed Forces Orientation to Engineering Careers (AFOTEC) and the Pre-Freshman and Cooperative Education (PREFACE) programs are viewed as means of attracting greater numbers of minority and female high school students into engineering schools, and of attracting engineering students to federal careers in E&S.

During the fourth quarter of FY 81, the staff of the EEO Office was increased by one space, allowing the permanent duty placement of a third-year DARCOM EEO Intern, formerly working at Letterkenny Army Depot at Chambersburg, PA. This intern's recent experience in the Civilian Personnel Office of that activity will be a valuable asset to the office.

HDL managers and supervisors continued to demonstrate their support of the EEO program by encouraging HDL personnel to attend the cultural awareness activities held during Black History Month, Hispanic Heritage Recognition Week,

Federal Women's Week, and Asian/Pacific Heritage Week. These activities included guest speakers, workshops, films, cultural artistic performances, and exhibits. This year also saw the inauguration of the Martin Luther King, Jr., Memorial Breakfast. This annual event serves not only to commemorate the birth of a great man, but also to rejuvenate in the workforce a concern for human dignity and equality of mankind.

Activity in the Upward Mobility Program (UMP) during FY 81 was progressive, with the identification of nine UMP jobs having target positions as follows: Accountant (3), Equipment Specialist (1), Engineering Technician (1), Supply Cataloguer (1), Management Analyst (1), Computer Specialist (1), and Personnel Staffing Specialist (1).

The total HDL workforce at the end of 1980 was 1,145 (20.5-percent minorities and 26.7-percent women). At the end of 1981, workforce strength had decreased slightly (6 percent) to 1079. Although there was a decrease in the total workforce, the representation of minorities and women in the workforce increased to 22.8 percent and 29.4 percent, respectively. Statistics for FY 81 also reveal that there was a decrease in the number of women in the General Schedule (GS) grades 1 to 5, but an increase in the number of women in grades 6 to 9, 10 to 12, and 13 and over (see table 7). Unfortunately, the statistical picture with regard to minorities in the overall GS grade structure is less favorable. The only grade group for which there was an increase in minority representation was in grades 6 through 9. However, the bright side of this fact is that this increase represents the movement of greater numbers of minorities into "technician" or paraprofessional jobs, as well as movement into the entry and lower mid-levels of professional job series. This, of course, is a major ingredient in upward mobility on a broad basis.

The posture for Wage Board employees has not changed significantly (see table 8); the reduction in minorities was more the result of retirements than of any other factor. The employment of women in wage board areas and their movement into the high grade levels continues to be a challenge.

In the area of special emphasis programs, there were three DARCOM Interns assigned to HDL from Red River Army Depot in Texarkana, Tex. Two of the interns were minority men (one black, one Hispanic) and one a minority woman (Hispanic). These assignments were the result of an innovative effort on the part of the ERADCOM/HDL Hispanic Employment Program Manager. It is expected that this pilot project will demonstrate the feasibility of assigning such interns to DARCOM laboratories before they enter the structured aspects of formal training.

Table 7. Grade Distribution—General Schedule Employees (as of 30 September 1981)

Category		FY	GS 1 to 5		GS 6 to 9		GS 10 to 12		GS 13 to 16	
No.	%		No.	%	No.	%	No.	%	No.	%
All employees										
983	100	80	207	21.1	166	16.9	350	35.6	260	26.4
918	100	81	186	20.3	168	18.3	327	35.6	237	25.8
Minorities										
149	15.2	80	43	28.9	41	27.5	50	33.6	15	10.1
166	18.1	81	39	23.5	53	31.9	59	35.5	15	9.0
Women										
287	29.2	80	155	54.0	87	30.3	41	14.3	4	1.4
298	32.4	81	149	50.0	97	32.5	45	15.1	7	2.3

Table 8. Grade Distribution—Wage Board Employees (as of 30 September 1981)

Category No.	Category %	FY	WG 1 to 5 No.	WG 1 to 5 %	WG 6 to 10 No.	WG 6 to 10 %	WG 11 to 15 No.	WG 11 to 15 %	Other nonsupv No.	Other nonsupv %	All WS[a] No.	All WS[a] %
All employees												
161	100	80	50	31.0	48	29.8	41	25.5	10	6.2	12	7.5
161	100	81	49	30.4	47	29.2	39	24.2	14	8.7	12	7.5
Minorities												
85	52.8	80	41	48.2	25	29.4	10	11.8	4	4.7	5	5.9
80	49.7	81	39	48.7	26	32.5	7	8.8	4	5.0	4	5.0
Women												
18	11.2	80	15	83.3	3	16.7	0	—	0	—	0	—
19	11.8	81	16	84.2	3	15.8	0	—	0	—	0	—

[a] *Wage supervisors*

HDL technology transfer report for FY 81

This is the sixth Military-Civilian Technology Transfer Report (CRCS CSCRD-172) of the Harry Diamond Laboratories (HDL). This report, which summarizes major aspects of the HDL Technology Transfer Program during FY 81, is provided pursuant to Army Regulation 70-57.

The Technology Transfer Program of HDL seeks to use the resources of the laboratories to identify and apply existing technology—knowledge, facilities, or capabilities—to problems faced by federal civilian agencies, state and local governments, and the private sector. Also, HDL cooperates with over 200 other federal laboratories in the Federal Laboratory Consortium for Technology Transfer (FLC). The representatives of the FLC laboratories form a person-to-person network to exchange information, refer inquiries, and develop ways to overcome common barriers to effective technology transfer.

The HDL program includes three major kinds of activities. (1) The program provides prompt responses to requests for information regarding technology (regardless of the source of the technology). This "technology brokerage" is an important component of the program, especially for state and local governments. (2) The program takes initiatives to identify civilian sector problems which might be solved through the application of HDL technology, to give visibility to HDL technology of potential commercial value, and to contribute to the program needs of civil agencies. The program provides relevant technical information and assistance to potential users. In special cases, HDL may develop funded projects to address special problems by adapting the technology. (3) The HDL program seeks improved technology transfer methods and participates in the regional and national activities of the FLC.

Activities Report. The first major kind of activity, the provision of information and technical assistance in response to inquiries, constituted about 20 percent of the program effort in FY 81. About 120 inquiries were received during the year. This number is down about 20 percent from the previous year. An analysis of the records shows that the decreased rate of inquiries occurred mainly in the second and third quarters of the fiscal year and probably reflects a period of unstable funding for a number of technology brokerage organizations representing state and local governments.

As usual, inquiries covering a great variety of subjects came from both direct users and brokers. For example, information (mainly on energy conservation) was provided for both individuals and local governments through the Delmarva Library Consortium. Also, a fair number of inquiries from the private sector were brought to HDL by the Ohio Technology Transfer Organization (OTTO). The most notable local government inquiry this year came from Fairfax, VA, which sought advice on procuring data loggers for building inspections. This inquiry provided the opportunity for a direct application of HDL expertise already adapted to problems of the U.S. Geological Survey.

The second major kind of activity, the initiation of contacts and development of projects to transfer HDL technology, constituted about 25 percent of

program effort. Of particular note during FY 81 were placing a major exhibit in the Baltimore Technology and Business Opportunities Conference (increasing the visibility of HDL technology in the private sector), working with the Department of Commerce Office of Minority Business Development to commercialize several fluidic innovations, and interaction with several agencies to apply fluidics to energy conservation. These were in addition to the on-going projects for the U.S. Geological Survey.

Funded projects which resulted from any of the contacts are presented in table 1, which shows the relevant project data. All these projects were funded entirely by a civilian agency sponsor; no cooperative projects were undertaken during the reporting period. The direct labor committed to these projects equalled 2 man years during FY 81.

The third program activity, participation in the national and regional activities of the FLC, continued as a principal effort in FY 81 with the passage of the Stevenson-Widler Act (PL 96-480). The specific mandate for technology transfer from the federal laboratories that this law provides has required not only the establishment of the Office of Research and Technology Application (ORTA), an easily identifiable contact point, but has specified that a required function of the office is cooperation with linking organizations such as the FLC. This, along with the recognition of FLC expertise in technology transer, has caused the FLC to increase its planning and coordination. These activities have provided valuable information to help in the required expansion of the HDL program, as well as strengthening the important outreach and dissemination mechanism provided by the FLC. Therefore, the HDL representative, in addition to his continued membership on the FLC Executive Committee, has served on several ad-hoc committees and task forces concerned with the implementation of PL 96-480. This as well as previous service was recognized during the past year when the HDL representative was chosen to receive the Harold Metcalf Award for his "contribution to technology transfer as a Consortium Representative."

Program Assessment. The increasing concern for technology transfer from the federal laboratories mentioned in previous reports was demonstrated this past year by the passage of PL 96-480 and the subsequent congressional hearings on its implementation. Although inquiries to the HDL program declined this past year as user brokers reorganized due to budget cuts, the need did not go away and, indeed, will be greater as fiscal restraint demands greater productivity from all sectors.

The HDL approach to technology transfer has been increasingly recognized as a leading example of an Army laboratory program. Now, in response to the specific requirement of PL 96-480, HDL has established a formal organizational element, the Technology Applications Branch of the Plans and Operations Office, to carry out the mandated functions, provide needed visibility, and allow for improved management of the effort.

Table 1. Technology Transfer Projects for FY 81

Projects	Sponsor	Science and technology area	Man years	Funding ($K)
Stream bed profiler	U.S. Geological Survey	Lasers	0.2	13.0
Mud-pulse telemetry	U.S. Geological Survey	Fluidics	1.1	207.0
Fluidic pyrometer	Department of Energy	Fluidics	0.5	41.0
Fluidic antiskid brakes	Department of Transportation	Fluidics	0.2	75.0
Computer for automated manufacturing	National Bureau of Standards	Minicomputers	0.1	3.0

appendices

awards and recognition

Hinman Award for Technical Leadership

Mark Miner

For his leadership and initiative in setting high standards and in establishing essential program objectives for the internal staff and for the effort by the contractor in support of the Patriot fuze development program. Engineering development of the Patriot fuze has been completed; a very successful flight-test program was conducted and type classification was completed through a total HDL and contractor effort, with Mr. Miner having a key leadership role.

Hinman Award for Technical Achievement

John Dammann

For his outstanding contributions in the development of aircraft target-signature models and innovative techniques for the employment of these models in the evaluation of radar proximity fuze performance. His efforts materially improved the Army's technical capability to assess quantitatively the effectiveness and comparative performance of the integrated structures of radar proximity fuzes and other elements of the air-defense system.

Ulrich Award for Managerial Leadership

CPT Vince Bernhard

For his outstanding leadership, determination, and dedication in the procurement process as a contracting officer and acting branch chief. He demonstrated an uncommon degree of management leadership, and has brought great credit to those elements of procurement and other HDL organizations with which he has been associated.

Ulrich Award for Managerial Achievement

Louis Schmitt

For his high degree of managerial achievement in facilities engineering resource management programs. He consistently prepared realistic and accurate budget planning and program execution for facilities engineering operations. He provided the skill and vigor necessary to successfully accomplish the objectives developed in those plans.

HDL Inventor of the Year Award

James S. Shreve

For his unique and important contributions which have advanced the technology of optical signal processing. His innovative concepts, pursued in a highly professional and dedicated manner, have resulted in a novel and effective means of achieving the phase and amplitude control necessary in many application areas.

Commander's Awards

Neil P. Lewis

For his many accomplishments while serving as Chief, Force Development Division, Personnel and Force Development Directorate, during the period 7 August 1978 through 10 July 1981. He distinguished himself by establishing a consistent

pattern of excellence as recognized through his previous receipt of honorary awards.

Albert Powell, Walter Collins, Carlton Anderson, William Sowers, John G. Steward, Allen C. Caldwell, and Thomas J. Bock

These employees witnessed a jeep accident involving a fellow government employee. Without regard to their own personal safety, they devised and implemented a rescue plan that resulted in saving the driver's life. These employees displayed exceptional competence and courage while rescuing the victim and exemplified personal qualities that reflect admirably on themselves and their organization.

Carl J. Campagnuolo

For his outstanding leadership and technical competence reflected in the success of his various projects.

Stuart M. Marcus

For his outstanding management of the CITA Process Review. Through his diligent efforts, a highly complicated process was successfully completed and substantial savings to the government were realized. He achieved outstanding results in improving the morale of workers in the organizational units under CITA with consequent improvement in work performance and esprit de corps.

Army Research and Development Awards

In FY 81, five HDL employees were honored with Army R&D awards. Donald E. Wortman and Herbert A. Dropkin were recognized for their work on the orotron. Norman J. Berg, Michael W. Casseday, and Irwin J. Abramovitz were honored for their work on the implementation of innovative acousto-optic signal-processing techniques.

Special Act or Service Awards

Five Special Act/Service Awards were given in FY 81 that equal or exceed $500.

Steven A. Boring received an $835 award in the first quarter for his work on the XM38 fuze setter.

Mark S. Miner received an $835 award in the fourth quarter for his work on the Patriot fuze at the fuze contractor's plant.

Michael A. Kolodny received an award of $2,200 in the fourth quarter for the implementation of his significant cost-savings suggestion pertaining to Patriot missile testing at the Patriot prime contractor's plant.

John Beilfuss received an award of $500 in the fourth quarter for his outstanding performance on the AN/TTC-39 EMP evaluation program.

Robert F. Gray received an award of $1,000 in the fourth quarter for his work on the AN/TTC-39 EMP evaluation program.

Student Technical Symposium

Winners of HDL's 22nd Annual Student Technical Symposium included

Ronald A. Frankel, First Prize Junior Level Winner, for his paper, *8085 Microprocessor-Based Jammer Control System,*

William O. Coburn, Second Prize Junior Winner, for his paper, *Microwave Conductivity Measurements and Diagnostic Techniques for AURORA SREMP Simulation Tests,*

Charles G. Garvin, First Place Senior Level Winner, for his paper, *Coherent and Incoherent Detection of Acousto-Optically Generated Fourier Transforms,* and

Clifford L. Sayre, Second Place Senior Level Winner, for his paper, *Characterization of a Test Fixture Using an Error Model.*

There was a tie for Third Place Senior Level:

Andrew Humen, *Microstrip Antenna Elements Fed by Transmission Line Coupling* and

Lawrence M. Burns, *A Generalized Signal Simulator for Frequency Modulated Fuzes.*

An Honorable Mention was awarded to Lloyd Linstrom for his paper, *Computer Aided Evaluation of a Signal Processor for an Electrostatic Fuzing System.*

Other Awards

In FY 81 there were 49 Outstanding Performance Ratings, 42 Honorary Awards, 52 Sustained Superior Performance Awards, 45 Special Act or Service Awards, and 27 Quality Step Increases. Forty-six suggestions were adopted.

Office of the Secretary of Defense Certificate of Appreciation

This certificate was awarded to Vondell Carter for exceptional meritorious service as an Equal Employment Opportunity Officer. The award was in recognition of his being directly responsible for originating, institutionalizing, and promoting the continuation of both internal and external mechanisms that have made a significant difference in the employment posture of blacks in the Department of Defense.

Harold Metcalf Award

For "Contributions to Technology Transfer as a Consortium Representative," this award was granted to Clifford E. Lanham. This "FLC Representative of the Year" award is made each year by a vote of the representatives of the laboratories (currently 195) which make up the Federal Laboratory Consortium for Technology Transfer, in recognition of past service.

formal reports

Technical Reports

Floyd Allen, *Two-Channel Telemeter for Use in a 3-in. Spin Air Gun,* HDL-TR-1961 (June 1981).

Anthony J. Baba and Stewart Share, *Vulnerability of Army Materiel to Thermal Radiation in Tactical Nuclear Environments (U),* HDL-TR-1937 (February 1981). (SECRET FORMERLY RESTRICTED DATA)

James C. Blackburn, *An Advanced 500-MHz-Bandwidth Fiber-Optic Signal Link for EMP and General Laboratory Applications,* HDL-TR-1940 (July 1981).

Harold E. Boesch, Jr., and James M. McGarrity, *Radiation Reponse and Modeling of Field-Oxide Structures (U),* HDL-TR-1922 (October 1980). (CONFIDENTIAL)

Howard E. Brandt, *Symmetries of the Nonlinear Conductivity for a Relativistic Turbulent Plasma,* HDL-TR-1927 (March 1981).

Philip S. Brody, *Investigations of Photovoltaic Ferroelectric-Semiconductor Nonvolatile Memory,* HDL-TR-1948 (March 1981).

Henry Bruns, Stephen C. Sanders, and Robert V. Garver, *High-Altitude Electromagnetic Pulse (HEMP) Assessment of the Siliconized AN/VRC-12 Radio Family (U),* HDL-TR-1938 (December 1980). (SECRET)

Andrew A. Cuneo, Jr., Joseph Capobianco, and John E. B. Tuttle, *XM-1 Tank EMP Susceptibility and Survivability Test Program, Final Report (U),* HDL-TR-1953 (June 1981). (SECRET)

Norman J. Doctor, *Cost-Reduced M587 Electronic Time Fuze: Root Cause Analysis of July 1979 Early Bursts,* HDL-TR-1945 (April 1981).

Raine M. Gilbert and John D. Hite, *Final Report on the Fabrication and Radiation Hardening of the ATRF System, II (U),* HDL-TR-1972 (July 1981). (SECRET RESTRICTED DATA)

Robert F. Gray, John W. Beilfuss, and Daniel J. Spohn, *EMP Verification Testing of the AN/TYC-39 Message Switch (U),* HDL-TR-1958 (June 1981). (SECRET)

Robert F. Gray (HDL) and David R. Gambrel (IBM Corp.), *A FORTRAN IV Computer Program for Designing and Implementing Recursive Digital Filters,* HDL-TR-1942 (June 1981).

Theodore H. Hopp, *On the Application of Pattern Recognition Techniques to Magnetic Influence Mine Fuze Design (U),* HDL-TR-1967 (August 1981). (CONFIDENTIAL)

Philip F. Ingersoll, *Artillery Delivered Unattended/Expendable Communication Jammer: Design Decisions, AD1 Model (U),* HDL-TR-1947 (March 1981). (CONFIDENTIAL)

Philip F. Ingersoll and Telemachos J. Manolatos, *NATO Sea Gnat Fuze: Design Review,* HDL-TR-1933 (April 1981).

John C. Ingram, *C^3 Modified TACWAR Model,* HDL-TR-1918 (May 1981).

Howard S. Jones, Jr., *Conformal and Small Antenna Designs,* HDL-TR-1952 (April 1981).

Bruno M. Kalab, *Damage Characterization of Semiconductor Devices for the AN/TRC-145 EMP Study,* HDL-TR-1915 (December 1980).

Hiralal C. Khatri, Richard T. Antony, Louis M. Tozzi, Wolfgang G. A. Wiebach, and Gerald M. Schultz, *Fuze for a Focused Blast Fragmentation Warhead (U),* HDL-TR-1955 (September 1981). (SECRET)

Richard P. Leavitt (HDL) and David Korff (University of Lowell), *Cutoff Theory of Impact Broadening and Shifting of Microwave and Infrared Molecular Spectra,* HDL-TR-1941 (January 1981).

Kendall T. LePoer, Louis J. Belliveau, Stanley Bukalski, Raymond H. Femenias, Joseph V. Michalowicz, Ralph G. Moore, Robert M. Spickler, Chris E. Spyropoulos, and Dennis P. Wilkins, *Nuclear Vulnerability of the Soviet Air Defense System (U),* HDL-TR-1912 (February 1981). (SECRET RESTRICTED DATA/NOFORN)

Dennis W. McGuire and Michael Conner, *The Deconvolution of Aerosol Backscattered Optical Pulses to Obtain System-Independent Aerosol Signatures,* HDL-TR-1944 (June 1981).

Dennis W. McGuire, Michael Conner, and Theodore H. Hopp, *Aerosol Discrimination by Electronic High- and Low-Pass Filtering,* HDL-TR-1939 (December 1980).

Joseph V. Michalowicz and John H. Wasilik, *Uncertainties in the Calculation of Damage Radii for Nuclear Projectiles (U),* HDL-TR-1935 (July 1981). (SECRET)

Joseph R. Miletta, *HEMP Assessment of the AUTOVON No. 1 ESS, Final Report (U),* HDL-TR-1950 (April 1981). (SECRET RESTRICTED DATA)

Timothy R. Oldham and James McGarrity, *Worst-Case Prediction of Single-Particle-Induced Permanent Failures in Microelectronics,* HDL-TR-1966 (July 1981).

Irvin Pollin, *Despin of a Highly Spinning Object: Despin of the Army's Unattended Expendable Jammer,* HDL-TR-1964 (September 1981).

Gary L. Roffman, *Electromagnetic Coupling Using Circuit-Analysis Programs,* HDL-TR-1957 (May 1981).

Charles Ruzic, *A Comparison of Field Components and Worst-Case Responses for the USANCA Threat and the WESTA EMP Simulator (U),* HDL-TR-1965 (July 1981). (CONFIDENTIAL)

Chris E. Spyropoulos, Joseph V. Michalowicz, and Ralph G. Moore, *An Assessment of the Survivability of the Lance Firing Battery to Warsaw Pact Tactical Nuclear Weapons (U),* HDL-TR-1914 (November 1980). (SECRET/NOFORN)

Kenneth W. Sweasy and Joseph V. Michalowicz, *Fighting Unit Survivability Evaluation (FUSE): Effectiveness Methodology (U),* HDL-TR-1923 (February 1981). (SECRET/NOFORN)

Michael J. Vrabel, *Bipolar Transistor and Diode Failure to Electrical Transients—Predictive Failure Modeling versus Experimental Damage Testing, 1: Junction Capacitance Damage Model,* HDL-TR-1959 (June 1981).

Ronald J. Wellman and Joseph Nemarich, *Short Pulse Nd:YAG Laser for Optical Fuze Applications,* HDL-TR-1946 (February 1981).

Wolfgang G. A. Wiebach and Barry L. Stann, *The Zero-Doppler Positioning System,* HDL-TR-1968 (September 1981).

Neil D. Wilkin, *Ionizing Radiation Susceptibility of Microprocessors,* HDL-TR-1949 (April 1981).

Colin S. Willett, *Unstable-Resonator and Output-Coupling Design Study for Diffraction Radiation Generator Near-Millimeter Sources,* HDL-TR-1936 (October 1980).

William T. Wyatt, Jr., and John F. Sweton, *NEMP Code Predictions Compared with EMP Data Measured During Nuclear Tests (U),* HDL-TR-1926 (December 1981). (SECRET RESTRICTED DATA—CNWDI)

Technical Memoranda

Chris Boykin and Mark Bumbaugh, *Vulnerability Assessment for TSEC/KW-7 Electronic Tactical Teletypewriter Security Equipment (U),* HDL-TM-81-1 (January 1981). (SECRET)

Morris Campi, Gary L. Roffman, and Joseph R. Miletta, *Standardization for Mitigation of High-Altitude Electromagnetic Pulse (HEMP),* HDL-TM-80-33 (December 1980).

Morris M. Campi, James D. Penar, and Joseph R. Miletta, *Development of High-Altitude Electromagnetic Pulse Design Practices,* HDL-TM-80-3 (December 1980).

Andrew A. Cuneo, Jr., *XM-1 Tank EMP Susceptibility and Survivability Test Program and Plan,* HDL-TM-80-25 (November 1980).

Andrew A. Cuneo, Jr., and James J. Loftus, *Scale Modeling for the PATRIOT Electromagnetic Pulse Test,* HDL-TM-81-16 (May 1981).

Andrew A. Cuneo, Jr., and James J. Loftus, *Measurement of Scaled-Down High-Altitude Electromagnetic Pulse (HEMP) Waveforms,* HDL-TM-81-6 (March 1981).

Jere D. Dando, George Gornak, and Thomas A. Rose, *Vulnerability Assessment of Data Processing Installation M127 by a Survivability Assessment Team (SAT) (U),* HDL-TM-80-12 (December 1980). (SECRET)

Richard Deadwyler, *Assessment of Two-Axis Fluidic Thrust Vector Control System for Ejection Seat Stabilization,* HDL-TM-81-20 (July 1981).

Adolphe J. Edwards, *An Evaluation of Currently Used Printed Circuit Board Materials and Processes,* HDL-TM-81-17 (May 1981).

Jonathan E. Fine, *Performance of Ram Air Driven Power Supply for Proposed High Altitude Rocket in Naval Surface Weapons Center Supersonic Wind Tunnel,* HDL-TM-80-31 (November 1980).

Robert V. Garver (HDL) and Charles Brown (Gichner, Inc.), *Radio Frequency Interference Evaluation of a Single Skin S-280B Shelter,* HDL-TM-81-7 (March 1981).

Timothy F. Geiger, *Performance of the R-Code System for Laser Guided Weapons (U),* HDL-TM-81-21 (August 1981). (SECRET)

Richard L. Goodyear and Henry Lee, *Performance of the Fluidic Power Supply for the XM445 Fuze in Supersonic Wind Tunnels,* HDL-TM-81-4 (February 1981).

John C. Ingram, *A Detailed Review of the TACWAR Model,* HDL-TM-80-15 (December 1980).

Christopher S. Kenyon, William T. Wyatt, and Daniel J. Spohn, *A Comparison of EMP Environments from ARES and from a Near-Surface Nuclear Burst Modeled by NEMP (U),* HDL-TM-80-32 (December 1980). (SECRET RESTRICTED DATA)

Klaus G. Kerris, *The AURORA Bremsstrahlung Environment,* HDL-TM-81-18 (July 1981).

George Mon, *The Design of a Fluidic Complementary Gain Changer,* HDL-TM-81-5 (February 1981).

Clyde A. Morrison and Richard P. Leavitt, *Line Broadening and Shifts of Rare-Earth Ion Energy Levels in Solids,* HDL-TM-80-30 (November 1980).

Heinz G. Mueller, Andrew A. Cuneo, Jr., MAJ Jack Munson (HQ USAREUR), Merle Ramsey (165th MI Bn), and SGT Roy L. Cox (USAREUR, OPM), *Assessment of DPI E005 by a Survivability Assessment Team (SAT) (U),* HDL-TM-81-14 (July 1981). (SECRET)

Eugene L. Patrick and Robert A. Pfeffer, *Survivability Assessment Team (SAT) Nuclear Weapons Effects Vulnerability Assessment of Data Processing Installation M104 (U),* HDL-TM-80-9 (February 1981). (SECRET)

Eugene L. Patrick and Robert A. Pfeffer, *Survivability Assessment Team (SAT) Nuclear Weapons Effects Vulnerability Assessment of Data Processing Installation M133 (U),* HDL-TM-80-8 (February 1981). (SECRET)

Robert A. Pfeffer and Eugene L. Patrick, *Survivability Assessment Team (SAT) Nuclear Weapons Effects Vulnerability Assessment of Data Processing Installation M191 (U),* HDL-TM-80-7 (February 1981). (SECRET)

Gary L. Roffman, *Application of Filters for High-Altitude Electromagnetic Pulse Protection,* HDL-TM-81-9 (April 1981).

Thomas A. Rose, *EMP Vulnerability Assessment of the AN/USM-410, a Computerized, Van-Mounted Electronic Equipment Test System,* HDL-TM-80-29 (April 1981).

Daniel H. Schaubert, Frederick G. Farrar, Arthur R. Sindoris, and Scott T. Hayes, *Post-Tuned Microstrip Antennas for Frequency-Agile and Polarization-Diverse Applications,* HDL-TM-81-8 (March 1981).

Charles T. Self, *Ionizing Radiation Effects on Four Random Access Memories,* HDL-TM-81-12 (April 1981).

Robert F. Shoemaker and Edwin H. Harrison, *Communications for High-Noise-Level Environments,* HDL-TM-81-11 (April 1981).

Werner J. Stark, David A. Clark, and Roy E. Strayer, Jr., *User's Manual for Electromagnetic Pulse Coupling Code TEMPO,* HDL-TM-81-2 (February 1981).

Alexander G. Stewart, *Upgrading the AURORA Simulator,* HDL-TM-80-28 (October 1980).

Kenneth W. Sweasy and Joseph V. Michalowicz, *Fighting Unit Survivability Evaluation (FUSE): TACFIRE System Survivability Analysis (U),* HDL-TM-80-17 (December 1980). (SECRET)

Michael J. Vrabel, *Bipolar Transistor and Diode Failure to Electrical Transients—Predictive Failure Modeling versus Experimental Damage Testing, 2: AFWL Transistor and Diode Failure Model,* HDL-TM-81-13 (June 1981).

James L. Washington and Robert V. Garver, *Lightning Damage Assessment and Hardening of a Wave-Staff Transducer,* HDL-TM-80-4 (December 1980).

Thomas R. Watt, *Radio Frequency Assemblies for the Advanced Technology Fuze System (U),* HDL-TM-81-10 (May 1981). (CONFIDENTIAL)

Neil D. Wilkin, *A Technique to Measure Oscillator Sensitivity,* HDL-TM-81-3 (February 1981).

Progress Reports

Richard Deadwyler, *A Review of Models of the Fluidic Generator,* HDL-PR-80-4 (November 1980).

Joseph V. Michalowicz, Ralph G. Moore, and John S. Wicklund, *Development of Methodology for Comparison of Timer and Proximity Fuzes for Nuclear Projectiles (U),* HDL-PR-80-5 (May 1981). (SECRET RESTRICTED DATA)

Stewart Share and John H. Wasilik, *Radiation-Hardened Fiber Optics: April 1979 to May 1980,* HDL-PR-81-1 (February 1981).

Paul A. Trimmer, *Vulnerability of Army Electronic Equipment to TRE: TH-22/TG, TD-352/U, TD-353/U, SN-421/TPX-50, C-7651, and RT-903/TPX-50 (U),* HDL-PR-80-3 (July 1981). (CONFIDENTIAL)

Paul A. Trimmer, Stewart Share, Louis J. Belliveau, and David P. Davis, *Nuclear Survivability Assessment for the Modular Universal Laser Equipment (MULE): AN/PAQ-3 (U),* HDL-PR-80-2 (December 1980). (CONFIDENTIAL RESTRICTED DATA)

Special Reports

Anthony J. Baba, Timothy R. Oldham, and Dale R. Schallhorn, *Summary of Thermomechanical Shock Investigations on Electronic Components (U),* HDL-SR-80-10 (December 1980). (SECRET FORMERLY RESTRICTED DATA)

Stanley H. Bukalski and William L. Vault, *Nuclear Weapons Effects Survivability Data Base for Common-Use Equipment: Program Concept and User's Guide,* HDL-SR-81-2 (June 1981).

Samuel A. Clark, Jr., Ronald J. Chase, and James D. Penar, *Facility Design Criteria AN/GSC-39(V)1*

Earth Terminal Complex Fixed Site Configuration, Addendum I: HEMP Considerations, HDL-SR-80-3 (March 1981).

John J. Furlani, Harry E. Hill, and Frank L. Tevelow, *Production Methodology for the Validation of Electronic Fuzes,* HDL-SR-80-11 (October 1980).

Timothy M. Geipe, *NUDACC (Nuclear Damage Assessment Computer Code) Programmer's Guide: Version II,* HDL-SR-81-3 (June 1981).

Alexander G. Stewart, *Camelot—A Novel Concept for a Multiterawatt Pulse Power Generator for Single Pulse, Burst, or Repetition Rate Operation,* HDL-SR-81-1 (April 1981).

publications and presentations

Electro-optics

Victoria M. Holliday and Raine Gilbert, *Cold-Induced Losses in Loose-Sheath Fiber Optic Cables,* presented at 25th Annual International Technical Symposium of the Society of Photo-Optical Instrumentation Engineers, 24-28 August 1981.

Joseph V. Michalowicz, *Analysis of the Laser-Guided Missile/Projectile versus Tank Counterfire Duel,* presented at Fifth ADPA (American Defense Preparedness Association) Vulnerability/Survivability Symposium, 18-20 November 1980.

Joseph Nemarich (HDL), James J. Gallagher, and Wayne M. Penn (Georgia Institute of Technology), *A Near-Millimeter Wave Mobile Measurement Facility,* presented at the Fifth International Conference on Infrared and Millimeter Waves, 6-10 October 1980.

Zoltan G. Sztankay, Dennis McGuire, James R. Griffin, Walter V. Hattery, Glendon H. Martin, and Gerald B. Wetzel, *Near-IR Extinction, Backscatter, and Depolarization of Smoke Week III Aerosols,* presented at Smoke/Obscurants Symposium V, 28-30 April 1981; published in Proceedings of the Smoke/Obscurants Symposium V, DRCPM-SMK-T-004-81, vol. I (August 1981), p 313.

Penetration of obscurants

Joseph Nemarich, Ronald J. Wellman, Domingo Rocha, Jr., and Gerald B. Wetzel, *Near-Millimeter Wave Measurements at SNOW-ONE,* presented at Snow Symposium I, 4-5 August 1981.

Joseph Nemarich, Ronald J. Wellman, Domingo Rocha, Jr., and Gerald B. Wetzel, *Near-Millimeter Wave Measurements of Propagation in Snow,* presented at DoD/NASA Meeting on Near-Millimeter Waves and Their Applications, 11-13 August 1981.

Joseph Nemarich, Ronald J. Wellman, Domingo Rocha, Jr., and Gerald B. Wetzel, *Characteristics of Near-Millimeter Wave Propagation in Snow,* presented at 25th Annual International Technical Symposium of the Society of Photo-Optical Instrumentation Engineers, 24-28 August 1981.

Electronic and signals warfare

Richard A. Kehs, Howard E. Brandt, and Alan Bromborsky, *Electron Distribution in the Relativistic Reflex Triode,* presented at 22nd Annual Meeting of the Division of Plasma Physics of the American Physical Society, 10-14 November 1980; abstract published, Bull. Am. Phys. Soc. **25** (1980), 888.

David T. Lokerson, *Army ARM/CM Program,* presented at Tri-Service ARM-CM Symposium, 7 April 1981; abstract published, Abstracts of April 1981 Tri-Service ARM-CM Symposium.

David T. Lokerson, *Terminal Phase Variable Deviated Pursuit Trajectories for Passive Seekers,* presented at Tri-Service ARM-CM Symposium, 7 April 1981; abstract published, Abstracts of April 1981 Tri-Service ARM-CM Symposium.

David T. Lokerson, *A Unique Digital Angle Error Detector and Emitter Location Tracker for Passive Seekers,* presented at Tri-Service ARM-CM Symposium, 7 April 1981; abstract published, Abstracts of April 1981 Tri-Service ARM-CM Symposium.

David T. Lokerson, *Tri-Service ARM-CM Program,* presented at 47th Symposium of Military Operations Research Society (MORS), 7 July 1981.

Fuzing

Collins Arsem, *Monopulse Fuzing,* presented at Annual Meeting of the Fuze Section of the Ammunition Technology Division, American Defense Preparedness Association, 17-18 March 1981.

Daniel W. Barr, *Low-Cost RF Proximity Fuzing,* presented at Annual Meeting of the Fuze Section of the Ammunition Technology Division, American Defense Preparedness Association, 17-18 March 1981.

Arthur R. Sindoris and Scott T. Hayes, *A Conical Array of Dielectric-Filled Edge Slot Radiators,* presented at International Antenna and Propagation Symposium, 15-19 June 1981; published in Digest of International Antenna and Propagation Symposium.

Nuclear weapons effects

Leedy G. Ambrose, Michael S. Bushell, Christopher Kenyon, George Merkel, and William D. Scharf, *Microwave Measurements of Conductivity in Air and Other Gases,* presented at IEEE Annual Conference on Nuclear and Space Radiation Effects, July 1981.

James C. Blackburn, *A Low-Noise Wideband Fiber-Optic Signal Link for EMP/SGEMP Instrumentation,* IEEE Trans. Nucl. Sci. **NS-27,** 6 (December 1980), 1616-1619.

J. R. Boller, J. D. Shipman, Jr., J. K. Burton, G. Cooperstein, R. A. Meeger (Naval Research Laboratory), George A. Huttlin, and Alexander G. Stewart (HDL), *AURORA Modifications for Positive Polarity Ion Diode Operation,* presented at 1981 IEEE International Conference on Plasma Science, 18-20 May 1981.

Howard E. Brandt, *Symmetries of the Nonlinear Conductivity Tensor for a Relativistic Turbulent Plasma,* presented at 22nd Annual Meeting of the Division of Plasma Physics of the American Physical Society, 10-14 November 1980; abstract published, Bull. Am. Phys. Soc. **25** (1980), 1035.

Howard E. Brandt, *Exact Symmetry of the Second Order Nonlinear Conductivity Tensor for a Relativistic Turbulent Plasma,* presented at 1981 Spring Meeting of the American Physical Society, 20-23 April 1981; abstract published, Bull. Am. Phys. Soc. **26** (1981), 588.

Howard E. Brandt, *Second Order Nonlinear Conductivity for an Unmagnetized Relativistic Turbulent Plasma,* presented at Workshop on Plasma Astrophysics, International School of Plasma Physics, 27 August to 7 September 1981.

Howard E. Brandt, *Exact Symmetry of the Second-Order Nonlinear Conductivity for a Relativistic Turbulent Plasma,* Phys. Fluids **24,** 9 (September 1981), 1760-1761.

Mark Bumbaugh and Sydney Rattner, *A Method to Assess the Combined Effects of Neutrons and Low Temperature on Transistor Circuits,* Radiat. Eff. Lett. **58,** 3 (1981), 97-101.

Michael S. Bushell, Stewart E. Graybill, Klaus G. Kerris, George Merkel, William D. Scharf, and Denis A. Whittaker, *The Direct Injection of Electron Pulses in Air—A SREMP Simulation Tool,* presented at the Third IEEE International Pulsed Power Conference, 1-3 June 1981.

Michael S. Bushell, Rolando P. Manriquez, George Merkel, and William D. Scharf, *Simulated Deep Source-Region EMP Coupling to Cylindrical Objects,* presented at IEEE Annual Conference on Nuclear and Space Radiation Effects, 20-24 July 1981.

Michael S. Bushell, Rolando P. Manriquez, George Merkel, and William D. Scharf, *Measurement and Calculation of the Short-Circuit SREMP Response of Vertical Oscillating Antennas and Oscillating*

Loop Antennas, presented at IEEE Annual Conference on Nuclear and Space Radiation Effects, 20-24 July 1981.

Michael S. Bushell, Rolando P. Manriquez, George Merkel, William D. Scharf, and Daniel J. Spohn, *Source Region EMP Simulator—A Parallel Plate Transmission Line in the AURORA Test Cell,* IEEE Trans. Nucl. Sci. **NS-27,** 6 (December 1980), 1834-1838.

Michael S. Bushell, Rolando P. Manriquez, George Merkel, William D. Scharf, and Daniel J. Spohn, *Capacitively and Inductively Loaded Antennas in a Source-Region EMP Environment,* IEEE Trans. Nucl. Sci. **NS-27,** 6 (December 1980), 1839-1844.

Michael S. Bushell, Rolando P. Manriquez, George Merkel, William D. Scharf, and Daniel J. Spohn, *An Equivalent Circuit for a Linear Oscillating Antenna Immersed in an Environment with Time-Varying Conductivity,* IEEE Trans. Nucl. Sci. **NS-27,** 6 (December 1980), 1857-1862.

Harvey Eisen and David Schoonmaker, *A Study of the Error in a Neutron Probability of Survival Formula,* IEEE Trans. Nucl. Sci. **NS-27,** 5 (October 1980), 1355.

Raine M. Gilbert, Howard C. Webb, and Timothy R. Oldham, *Transient Response of Optical Fibers Exposed to Pulsed Radiations,* IEEE Trans. Nucl. Sci. **NS-27,** 6 (December 1980), 1864-1870.

Klaus G. Kerris, Stewart E. Graybill, and Denis A. Whittaker, *AURORA—A Versatile, Multi-mission Simulation Facility,* presented at 18th Annual IEEE Conference on Nuclear and Space Radiation Effects, 20-24 July 1981.

Kendall T. LePoer and Ronald J. Chase, *A Test Facility for Verification of EMP Hardening Techniques for Fixed Sites,* presented at 18th Annual IEEE Conference on Nuclear and Space Radiation Effects, 20-24 July 1981.

James M. McGarrity, *Considerations for Hardening MOS Devices and Circuits for Low Radiation Doses,* IEEE Trans. Nucl. Sci. **NS-27,** 6 (December 1980), 1739-1744.

Flynn B. McLean, *A Framework for Understanding Radiation-Induced Interface States in SiO_2 MOS Structures,* IEEE Trans. Nucl. Sci. **NS-27,** 6 (December 1981), 1651-1657.

Flynn B. McLean, Peter S. Winokur, and Harold E. Boesch, Jr., *Toward A Model of Radiation-Induced Interface States in SiO_2 MOS Structures,* presented at 1980 IEEE Semiconductor Interface Specialists Conference, 8-10 December 1980, and also at 1981 March Meeting of the American Physical Society, March 1981; published in Bull. Am. Phys. Soc. **26** (1981), 219.

R. A. Meeger, F. C. Young, A. T. Drobot, G. Cooperstein, S. A. Goldstein, D. Mosher (Naval Research Laboratory), Stewart E. Graybill, George A. Huttlin, Klaus G. Kerris, and Alexander G. Stewart (HDL), *High Impedance Ion Diode Experiment on AURORA,* Naval Research Laboratory, Memorandum Report 4477 (19 March 1981).

Joseph V. Michalowicz, *Evaluation of Nuclear Artillery Battery Coverage,* presented at 46th Symposium of Military Operations Research Society (MORS), 2-4 December 1980; published in Proceedings, 46th MORS Symposium, 101-112.

Joseph V. Michalowicz and Kenneth W. Sweasy, *Evaluation of Fighting Unit Survivability,* Proceedings of 19th Annual U.S. Army Operations Research Symposium (AORS), vol. 4 (October 1980), 758-771.

Timothy R. Oldham and James M. McGarrity, *Single-Particle Induced Permanent Failures of VLSI Memories,* presented at Electrochemical Society Meeting, 5-10 October 1980.

Timothy R. Oldham and James M. McGarrity, *Ionization of SiO_2 by Heavy Charged Particles,* presented at 18th Annual IEEE Conference on Nuclear and Space Radiation Effects, 21-24 July 1981.

Dale R. Schallhorn, Stewart E. Graybill, Klaus G. Kerris, Alexander G. Stewart, and George A. Huttlin, *The AURORA Facility,* presented at Aeroballistic Range Association Conference, 8 October 1980; published in Proceedings of Aeroballistic Range Association Conference.

Alexander G. Stewart, *Status Report on HDL's Pulse Power Programs,* presented at Pulse Power Tactical Advisory Group Meeting, February 1981.

Kenneth W. Sweasy and Joseph V. Michalowicz, *Impact of Tank Protective Liner on Battlefield Effectiveness,* presented at 47th Military Operations Research Symposium, 8 July 1981.

John H. Wasilik, *Effects of Thermal Radiation on Selected Optical Components,* IEEE Trans. Nucl. Sci. **NS-27,** 6 (December 1980), 1632-1639.

Neil D. Wilkin, Charles T. Self, and Harvey Eisen, *Ionizing Dose Rate Effects in Microprocessors,* IEEE Trans. Nucl. Sci. **NS-27,** 6 (December 1980), 1420-1424.

Peter S. Winokur, Harold E. Boesch Jr., and Flynn B. McLean, *Field-Switching Experiments to Define Mechanisms of Radiation-Induced Interface-State Buildup,* presented at 1981 March Meeting of the American Physical Society, 16-20 March 1981; published in Bull. Am. Phys. Soc. **26** (1981), 219.

F. C. Young, R. A. Meeger, D. P. Bacon, J. J. Condon, G. Cooperstein, S. A. Goldstein, D. Mosher (Naval Research Laboratory), Stewart E. Graybill, George A. Huttlin, Klaus G. Kerris, Alexander G. Stewart, Denis A. Whittaker, R. Bixby, Marc S. Litz (HDL), and C. W. Mandell (Sandia National Laboratory), *Ion-Diode Experiments in Positive Polarity on AURORA,* presented at 22nd Annual Meeting of the Division of Plasma Physics, 10-14 November 1980; published in Bull. Am. Phys. Soc. **25** (October 1980), 899.

Fluidics

Richard Deadwyler, *A Review of Two-Stage Servovalve Development Using a First-Stage Fluidic Amplifier,* presented at ASME 20th Anniversary of Fluidics Symposium, 17-18 November 1980; published in Proceedings of the 20th Anniversary of Fluidics Symposium (December 1980), ASME WAM80.

Tadeusz M. Drzewiecki, *A High-Order, Lumped Parameter, Jet Dynamic Model for the Frequency Response of Laminar Proportional Amplifiers,* presented at ASME 20th Anniversary of Fluidics Symposium, 17-18 November 1981; published in Proceedings of the 20th Anniversary of Fluidics Symposium (December 1980), ASME WAM80.

Tadeusz M. Drzewiecki, *A Fluidic Audio Intercom,* presented at ASME 20th Anniversary of Fluidics Symposium, 17-18 November 1981; published in Proceedings of the 20th Anniversary of Fluidics Symposium (December 1980), ASME WAM80.

R. Michael Phillippi (HDL) and Taki Negas (National Bureau of Standards), *A Preliminary Industrial Evaluation of the Fluidic Capillary Pyrometer,* presented at ASME 20th Anniversary of Fluidics Symposium, 17-18 November 1980; published in Proceedings of the 20th Anniversary of Fluidics Symposium (December 1980), ASME WAM80.

Devices and technology

Philip S. Brody, *Photovoltaic and Other Outputs from Pulsed Laser Illuminated Ferroelectrics,* presented at Fifth International Meeting on Ferroelectricity, 16-24 August 1981; published in Proceedings of Fifth International Conference on Ferroelectricity.

Philip S. Brody, *Photovoltaic and Other Electric Outputs Generated in Ferroelectrics by Homogeneous Illumination Pulses,* presented at Fifth International Meeting on Ferroelectricity, 16-24 August 1981; published in Proceedings of Fifth International Conference on Ferroelectricity.

Philip S. Brody, *Semiconductor-Ferroelectric Nonvolatile Memory Using Anomalous High Photovoltages in Ferroelectric Ceramics,* Appl. Phys. Lett. **38,** 3 (1 February 1981), 153-155.

Philip S. Brody, Adolphe J. Edwards, and Emanuel Katzen, *Array Optical Detector Based on Anomalous Photovoltaic Effect in Ferroelectric Ceramic,* presented at 83rd Annual Meeting of the American Ceramic Society, 3-6 May 1981; published in Collected Abstracts of 83rd Annual Meeting of the American Ceramic Society.

Morris Campi, *Design of Microstrip Linear Array Antennas,* presented at 1981 Antenna Applications

Symposium, 23-25 September 1981; published in Proceedings of the 1981 Antenna Applications Symposium, HDL-PP-81-RTA-2.

Herbert Dropkin, Richard P. Leavitt, and Donald E. Wortman, *Design and Operation of a 75-GHz Orotron,* presented at DoD/NASA Meeting on Near-Millimeter Waves and Their Applications, 11-13 August 1981.

Herbert Dropkin, Richard P. Leavitt, and Donald E. Wortman, *Design and Operation of the Orotron—A Tunable Source of Coherent Millimeter Wave Radiation,* presented at International Microwave Symposium, 16 June 1981; published in IEEE Proceedings of the International Microwave Symposium.

Herbert Dropkin, John N. Lee, and Norman J. Berg, *Decay Time Constants of Photoinduced Stored SAW Patterns in* $LiNbO_3$, presented at Ultrasonics Symposium, November 1980; published in Proceedings of Ultrasonics Symposium.

Frederick G. Farrar, *Millimeter Wave W-Band Slotted Waveguide Antennas,* presented at IEEE/APS and URSI International Symposium, 15-19 June 1981; published in Proceedings, IEEE/APS and URSI International Symposium.

Frederick G. Farrar, *Near-Millimeter Wave Antennas,* presented at Joint DoD/NASA Meeting on Near-Millimeter Waves and Their Applications, 11-13 August 1981.

Horst W. A. Gerlach and Ronald J. Wellman, *The Behavior of a Pulsed Millimeter Wave IMPATT Diode Oscillator During Laser Illumination,* presented at Electrophysics Seminar, University of Maryland, 31 October 1980.

John N. Lee, Norman J. Berg, Michael W. Casseday, and Philip S. Brody, *High-Speed Adaptive Filtering and Reconstruction of Broad-Band Signals Using Acousto-Optic Techniques,* presented at Ultrasonics Symposium, November 1980; published in Proceedings of Ultrasonics Symposium.

Dieter R. Lohrmann, *Op-amp Summer Forms Simple High-Speed Phase Generator,* Electronics (4 December 1980), 146-147.

Dennis McGuire, *A Solution of an Inverse-Source Problem in Coherence Theory,* J. Math. Phys. **21**, 11 (November 1980), 2686-2689.

Stephen J. Price, Robert E. Isliefson, R. James Ryan (Honeywell, Inc.), and Allan B. Goldberg (HDL), *Rapidly Demoldable Encapsulants for Ordnance Electronics,* presented at 39th Annual Technical Conference of the Society of Plastics Engineers, 4-7 May 1981; published in Society of Plastics Engineers, Inc., Technical Papers, vol. XXVII, p 938.

Joseph P. Sattler, *Tunable Diode Laser Infrared Heterodyne Spectroscopy of Gases,* presented to Washington Chapter, Optical Society of America, 20 January 1981.

Joseph P. Sattler, Lewis S. Miller, and Terrance L. Worchesky, *Diode Laser Heterodyne Measurements on* $^{14}NH_3$, J. Molecular Spectroscopy **88** (August 1981), 347-351.

Joseph P. Sattler, Lewis S. Miller, and Terrance L. Worchesky, *Infrared Diode Laser Heterodyne Measurements on* $^{14}NH_3$, presented at 36th Symposium on Molecular Spectroscopy, 15-19 June 1981; published in Collected Abstracts of 36th Symposium on Molecular Spectroscopy, p 116.

Joseph P. Sattler and Terrance L. Worchesky, *Infrared and Submillimeter Wave Transitions in Fluorinated Methane Molecules,* presented at Fifth International Conference on Infrared and Millimeter Waves, 6-10 October 1980; published in Proceedings of Fifth International Conference on Infrared and Millimeter Waves.

Joseph P. Sattler, Terrance L. Worchesky (HDL), and Walter J. Lafferty (National Bureau of Standards), *Diode Laser Heterodyne Spectroscopy on the* ν_1 *Band of Sulfur Dioxide,* J. Molecular Spectroscopy **88** (August 1981), 364-371.

Joseph P. Sattler, Terrance L. Worchesky (HDL), and Walter J. Lafferty (National Bureau of Standards), *Diode Laser Heterodyne Spectroscopy of Sulfur Dioxide,* presented at Topical Meeting on Spectroscopy in Support of Atmospheric Measurements, 10-12 November 1980; published in Collected Summaries of Topical Meeting on

Spectroscopy in Support of Atmospheric Measurements.

Joseph D. Silverstein, Robert M. Curnutt (HDL), and M. E. Read (Naval Research Laboratory), *A Second-Harmonic Gyromonotron at 1 mm,* presented at DoD/NASA Meeting on Near-Millimeter Waves and Their Applications, 11-13 August 1981.

Joseph D. Silverstein (HDL) and M. E. Read (Naval Research Laboratory), *A 240-GHz Gyromonotron,* presented at 1981 IEEE International Conference on Plasma Science, 18-20 May 1981; published in IEEE Conference Record—Abstracts, 1981 IEEE International Conference on Plasma Science, p 124.

George J. Simonis and Robert D. Felock, *Near-Millimeter Wave Duplexers,* presented at Fifth International Conference on Infrared and Millimeter Waves, 6-10 October 1980; published in Proceedings of Fifth International Conference on Infrared and Millimeter Waves.

George J. Simonis, and Robert D. Felock, *Quasi-Optical Near-Millimeter Optical Constant Measurements,* presented at Fifth International Conference on Infrared and Millimeter Waves, 6-10 October 1980; published in Proceedings of Fifth International Conference on Infrared and Millimeter Waves.

George J. Simonis, Gary L. Wood, and Joseph P. Sattler, *Sulfur Dioxide Far-Infrared Pulsed-Laser Operation,* presented at International Conference on Lasers '80, 14-19 December 1980; published in Conference Digest, Lasers '80.

Josip Soln, *Free Electron Cerenkov Laser as a Possible NMMW Source,* presented at International Conference on Lasers '80, 14-19 December 1980; abstract published in Conference Digest, Lasers '80.

Josip Soln, *Free Electron Cerenkov Laser,* presented at Fifth International Conference on Infrared and Near-Millimeter Waves, 6-10 October 1980; abstract published in Conference Digest, Fifth International Conference on Infrared and Near-Millimeter Waves.

Mary S. Tobin, *CW Submillimeter Wave Laser Pumped by an RF-Excited CO_2 Waveguide Laser,* presented at SPIE Electro-Optical Symposium, Millimeter Optics, 29 September to 2 October 1980; published in SPIE Proceedings, vol. 259, pp 13-17.

Mary S. Tobin, *Optically Pumped Sources,* presented at DoD/NASA Meeting on Near-Millimeter Waves and Their Applications, 9-12 August 1981.

Mary S. Tobin and Thomas W. Daley, *CW SMMW Laser Pumped by a CO_2 Waveguide Laser,* presented at International Conference on Lasers '80, 14-19 December 1980.

Mary S. Tobin and Robert D. Felock, *Fluoroform-d Optically Pumped Submillimeter-Wave Laser,* Optics Letters **5** (1 October 1980), 430-432.

Mary S. Tobin (HDL) and G. A. Koepf (NASA Goddard Space Flight Center and Phoenix Corp.), *Characteristics of CDF_3 and $^{13}CD_3F$ Optically Pumped cw Submillimeter Wave Lasers,* presented at Fifth International Conference on Infrared and Millimeter Waves, 6-10 October 1980; published in Proceedings of Fifth International Conference on Infrared and Millimeter Waves.

Bruce A. Weber and Stanley M. Kulpa, *A Comparative Study of the [Hg,Cd]Te and InSb Hot-Electron Bolometers,* presented at International Conference on Lasers '80, 14-19 December 1980.

Bruce A. Weber and Stanley M. Kulpa, *Responsivity Enhancement in Compensated Indium Antimonide Detectors,* presented at Fifth International Conference on Infrared and Millimeter Waves, 6-10 October 1980; published in Conference Digest, Fifth International Conference on Infrared and Millimeter Waves, p 366.

Bruce A. Weber and Stanley M. Kulpa, *A New Broadband Near-Millimeter-Wave Detector Using Mercury-Cadmium-Telluride,* presented at the 4th International Conference on the Physics of Narrow-Gap Semiconductors, 14-17 September 1981; published in Proceedings of the 4th International Conference on the Physics of Narrow-Gap Semiconductors.

Peter S. Winokur and Harold E. Boesch, Jr., *Interface-State Generation in Radiation-Hard Oxides,* IEEE Trans. Nucl. Sci. **NS-27**, 6 (December 1980), 1647-1650.

Peter S. Winokur and Harold E. Boesch, Jr., *Long-Term Annealing of MOS Capacitors,* presented at 18th Annual IEEE Conference on Nuclear and Space Radiation Effects, 21-24 July 1981.

Peter S. Winokur and Harold E. Boesch, Jr., *Annealing of MOS Capacitors with Implications for Test Procedures to Determine Radiation Hardness,* presented at 18th Annual IEEE Conference on Nuclear and Space Radiation Effects, 21-24 July 1981.

Firefinder

Michael P. Parker, Gary L. Roffman, and Hiralal C. Khatri, *ARM-CM for the Firefinder Radar (U),* presented at Tri-Service ARM-CM Symposium, 7-9 April 1981 (CONFIDENTIAL); abstract published in Collected Abstracts of Tri-Service ARM-CM Symposium (U), p 35.

Other

James C. Blackburn, *An Analog Fiber-Optic Signal Link for EMP Instrumentation,* presented at EMP Simulation and System Hardening Symposium, 28-30 October 1980; published in Proceedings of EMP Simulation and System Hardening Symposium.

Frank J. Crowne and Terrance L. Worchesky, *Superlattice Inelastic-Tunneling Millimeter-Wave Source,* presented at DoD/NASA Meeting on Near-Millimeter Waves and Their Applications, 11-13 August 1981.

Frank J. Crowne, Richard P. Leavitt, and Terrance L. Worchesky, *Exactly Solvable Nonlinear Model of a Smith-Purcell Free-Electron Laser,* presented at 1981 Spring Meeting of the American Physical Society, 20-23 April 1981; published in Phys. Rev. A **24** (August 1981), 1154-1157.

John B. Gruber (Portland State University), N. C. Chang (Aerospace Corporation), Richard P. Leavitt, and Clyde A. Morrison (HDL), *Optical Spectra, Energy Levels, and Crystal-Field Parameters of Tripositive Rare Earth Ions in Y_2O_3: I. Kramers Ions in C_2 Sites,* presented at Fifteenth Rare Earth Research Conference, June 1981.

Richard P. Leavitt (HDL), N. C. Chang (Aerospace Corporation), Clyde A. Morrison (HDL), and John B. Gruber (Portland State University), *Optical Spectra, Energy Levels, and Crystal-Field Parameters of Tripositive Rare Earth Ions in Y_2O_3: II. Non-Kramers Ions in C_2 Sites,* presented at Fifteenth Rare Earth Research Conference, June 1981.

Richard P. Leavitt and Clyde A. Morrison, *Contributions to the Second Virial Coefficient from the Anisotropic Interaction Potential for Molecules of Arbitrary Symmetry,* Chem. Phys. Lett. **76** (1981), 341.

Richard P. Leavitt, Donald E. Wortman, and Herbert Dropkin, *Nonlinear Theory of a Smith-Purcell Free-Electron Laser,* presented at 1981 Spring Meeting of the American Physical Society, 20-23 April 1981.

Clyde A. Morrison (HDL), John B. Gruber (Portland State University), N. C. Chang (Aerospace Corporation), and Richard P. Leavitt (HDL), *Optical Spectra, Energy Levels, and Crystal-Field Parameters of Tripositive Rare Earth Ions in Y_2O_3: III. C_{3i} Sites and Theoretical Overview,* presented at Fifteenth Rare Earth Research Conference, June 1981.

Clyde A. Morrison and Richard P. Leavitt, *Crystal-Field Analysis of Nd^{3+} and Er^{3+} in $Bi_4Ge_3O_{12}$*, J. Chem. Phys. **74** (1 January 1981), 25.

Clyde A. Morrison, Terrance L. Worchesky, Richard P. Leavitt (HDL), H. P. Christensen, H. P. Jenssen, and D. R. Gabbe (Massachusetts Institute of Technology), *Optical Spectra, Energy Levels, and Crystal-Field Parameters of Holmium in Rb_2NaHoF_6,* presented at Fifteenth Rare Earth Conference, June 1981.

publications and presentations

Joseph P. Sattler, Terrance L. Worchesky (HDL), and Walter J. Lafferty (National Bureau of Standards), *Infrared and Submillimeter Wave Analyses of Optically Pumped Molecules,* presented at DoD/NASA Meeting on Near-Millimeter Waves and Their Applications, 11-13 August 1981.

Josip Soln, *Stimulated Electron Radiation in a Medium Due to Wiggler Magnet,* J. Appl. Phys. **51,** 10 (October 1980), 5523.

John G. Stewart, Jr., and William A. Petty, *High-Voltage Monitoring and Control Through Fiber Optics,* presented at Conference on Measurement of Electrical Quantities in Pulse Power Systems (2-4 March 1981).

Della A. Whittaker, *Write for Your Reader,* IEEE Trans. Prof. Commun. **PC-23,** 4 (December 1980), 170-173.

Terrance L. Worchesky and George J. Simonis, *Near-Millimeter Wave Spectroscopy of Materials,* presented at DoD/NASA Meeting on Near-Millimeter Waves and Their Applications, 11-13 August 1981.

Donald E. Wortman, Herbert Dropkin, and Richard P. Leavitt, *Generation of Millimeter-Wave Radiation by Means of a Smith-Purcell Free-Electron Laser,* presented at 1981 Spring Meeting of the American Physical Society, 20-23 April 1981.

united states patents

4,227,092

Campagnuolo et al. **Oct. 7, 1980**

[54] **HAND CRANKED ELECTRICAL POWER SOURCE**

[75] Inventors: **Carl J. Campagnuolo,** Potomac; **Leon Scheinine,** Adelphi; **Paul M. Mayercik,** Wheaton, all of Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

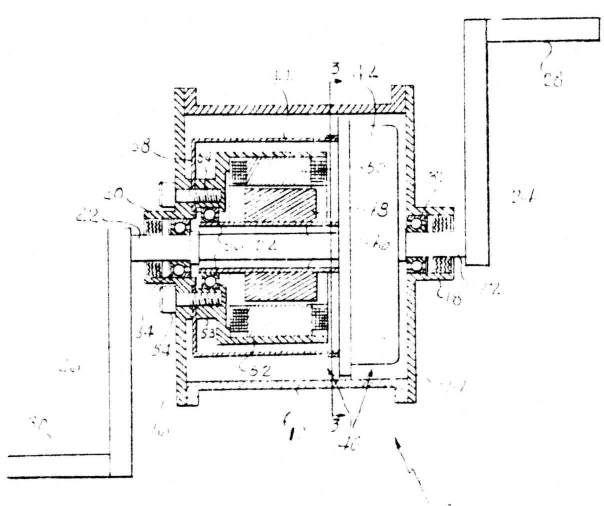
[21] Appl. No.: **855,859**

[22] Filed: **Nov. 30, 1977**

[57] **ABSTRACT**

A hand-cranked power source intended for use in emergency situations to generate electrical energy. The power source features a lightweight construction as well as the ability to generate a reasonable amount of power. The preferred embodiment couples an input drive shaft to a harmonic drive system having a high speed output shaft. Upon the output shaft are preferably mounted samarium cobalt magnets forming the rotor of a three phase alternator. The output of the alternator may be utilized to power a field device, such as a radio, or the like, or may be used to charge fast-charging batteries.

11 Claims, 3 Drawing Figures



4,227,195

Salerno et al. **Oct. 7, 1980**

[54] **FUZE**

[75] Inventors: **James Salerno,** Rockville; **Fabian T. Liss,** Bethesda, both of Md.; **Frank Weiss,** Washington, D.C.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

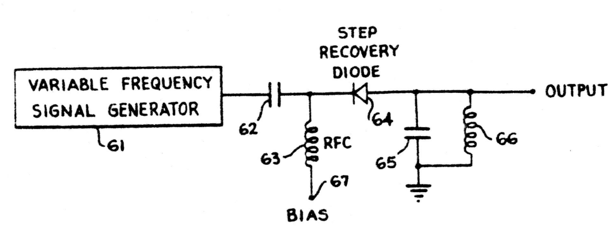
[21] Appl. No.: **311,609**

[22] Filed: **Sep. 19, 1963**

[57] **ABSTRACT**

1. A radar signal code generator comprising:
   a. first oscillator means comprising an output terminal for producing, at said terminal, a continuous sinusoidal wave having a continuously varying frequency; and
   b. pulse generator means operatively connected to said first oscillator means output terminal for producing a plurality of pulses, each of which consists of a constant frequency carrier wave, the initiation of each of said pulses occurring at a predetermined time interval after a respective cycle of said sinusoidal wave from said first oscillator means reaches a selected phase value.

6 Claims, 8 Drawing Figures



4,227,462

Tucker **Oct. 14, 1980**

[54] **LOCK OUT PROXIMITY FUZE AMPLIFIER**

[75] Inventor: **Robert W. Tucker**, Rockville, Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, D.C.

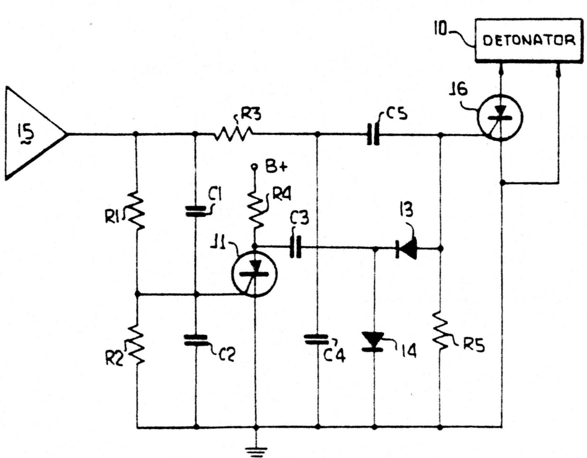
[21] Appl. No.: **553,359**

[22] Filed: **Feb. 28, 1975**

[57] **ABSTRACT**

A discriminator circuit having utility in proximity fuze firing circuits is capable of distinguishing between spurious and proper signals on the basis of both amplitude and rate of amplitude rise. A firing switch, operated by a slow-charging trigger circuit, and a lock out switch, operated by a fast-charging trigger circuit, are both triggered by the same signal. If the rate of input signal envelope rise is faster than that for a proper firing signal, the lock out switch fires and inhibits triggering of the firing switch. The trigger circuits are biased to permit the firing switch to be triggered before the lock out switch when the input signal rate of rise is slow enough to be followed by the slow-charging trigger circuit. For signal rates of rise which are slower than that associated with a proper signal, a capacitor in the slow-charging trigger circuit becomes charged to block triggering of the firing switch.

10 Claims, 2 Drawing Figures



4,235,516

Shreve **Nov. 25, 1980**

[54] **COMPLEX SPATIAL MODULATOR**

[75] Inventor: **James S. Shreve**, Fairfax, Va.

[73] Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, D.C.

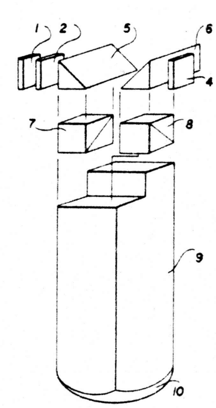
[21] Appl. No.: **19,032**

[22] Filed: **Mar. 9, 1979**

[57] **ABSTRACT**

An apparatus for effecting independent spatial amplitude and phase modulation of a light beam. Two birefringent crystal modulation means such as PROM's (Pockel's Readout Optical Modulator) are arranged so that the first modulation means spatially modulates the amplitude of the beam in accordance with an input image applied to the first modulation means while the second modulation means spatially modulates the phase of the beam in accordance with an input image which is applied to the second modulation means.

7 Claims, 3 Drawing Figures



4,236,188

Prochazka **Nov. 25, 1980**

[54] **COAXIAL TERMINAL PROTECTION DEVICE WITH DISPOSABLE CARTRIDGE**

[75] Inventor: **Rudolph J. Prochazka,** Springfield, Va.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

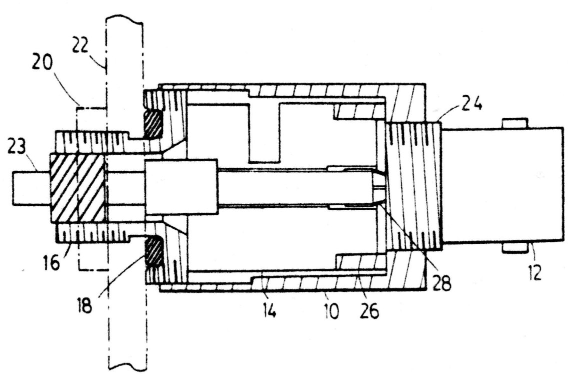
[21] Appl. No.: **3,179**

[22] Filed: **Jan. 15, 1979**

[57] **ABSTRACT**

Protective electronic circuitry is disclosed using coaxial connector technology and incorporating a disposable cartridge containing an electronic circuit for protecting communication equipment having coaxial inputs.

11 Claims, 7 Drawing Figures



4,236,938

Brody **Dec. 2, 1980**

[54] **EFFICIENT HIGH VOLTAGE PHOTOVOLTAIC CELLS**

[75] Inventor: **Philip S. Brody,** Brookmont, Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

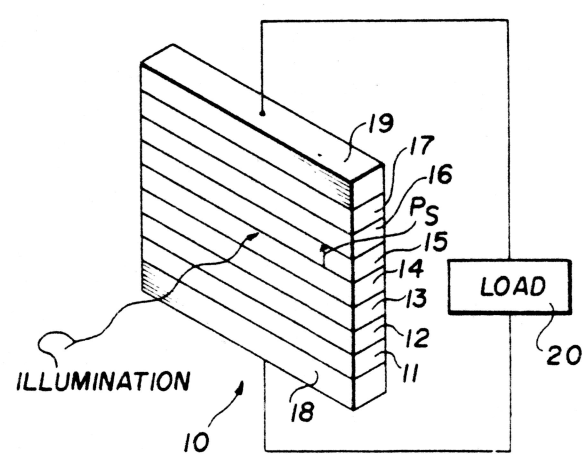
[21] Appl. No.: **60,525**

[22] Filed: **Jul. 25, 1979**

[57] **ABSTRACT**

A photovoltaic cell comprised of a plurality of single crystal, remanently polarized, ferroelectric layers in a stack with electrodes affixed to each end. Additionally, electrodes are disposed between adjacent layers or conductive or semi-conductive regions are formed at and near the interfaces between layers by chemical reduction or doping. The cell has a higher conversion efficiency than ferroelectric cells heretofore known.

11 Claims, 8 Drawing Figures



4,238,797

Shreve **Dec. 9, 1980**

[54] **MULTI-BEAM ANTENNA CONTROLLER**

[75] Inventor: **James S. Shreve,** Fairfax, Va.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

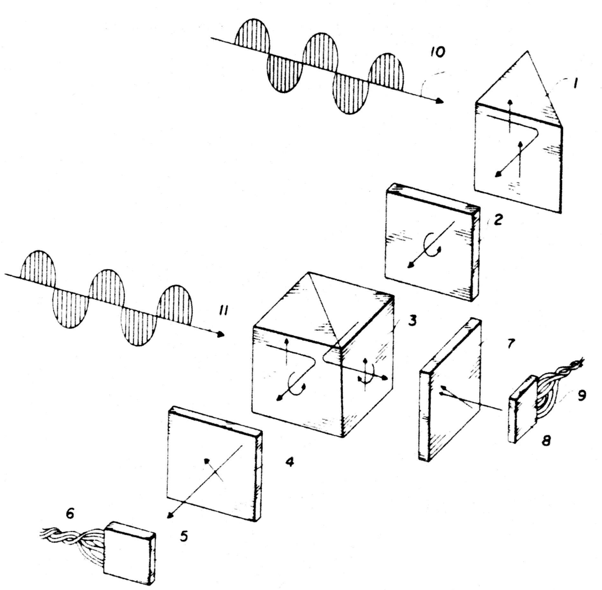
[21] Appl. No.: **42,688**

[22] Filed: **May 25, 1979**

[57] **ABSTRACT**

An optical processor antenna controller for controlling a plurality of beams emitted from an array antenna. The beams may be emitted simultaneously or sequentially, and control is by a plurality of coherent light beams.

4 Claims, 13 Drawing Figures



4,241,351

Shreve **Dec. 23, 1980**

[54] **ARRAY ANTENNA CONTROLLER**

[75] Inventor: **James S. Shreve,** Fairfax, Va.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

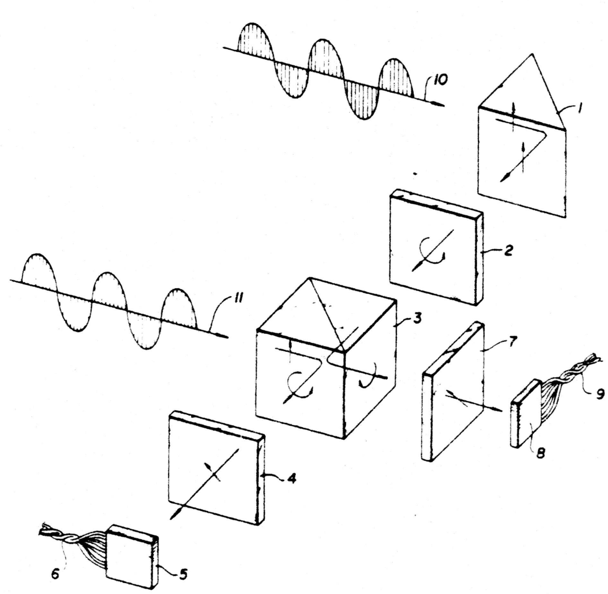
[21] Appl. No.: **29,421**

[22] Filed: **May 11, 1979**

[57] **ABSTRACT**

A coherent optical processor antenna controller for controlling the pattern emitted by an array antenna. Since the amplitude and phase of the antenna excitation signals are related to the far field by the Fourier transform function, a coherent optical processor, which uses lenses to take the Fourier transforms of images may be used to control the antenna excitation. The shape and direction of the pattern may be controlled by the transmittance distribution of a transparency in the processor and a null may be formed by the utilization of an additional slide.

7 Claims, 11 Drawing Figures



4,241,760

Mon **Dec. 30, 1980**

[54] **FLUIDIC VALVE**

[75] Inventor: **George Mon,** Silver Spring, Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

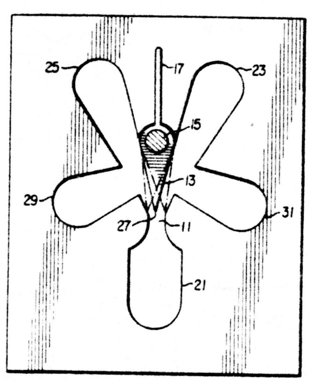
[21] Appl. No.: **8,627**

[22] Filed: **Feb. 1, 1979**

[57] **ABSTRACT**

A fluidic valve which includes a supply nozzle for discharging a fluid power stream, and a pair of outlet channels for receiving the power stream. A rigid member is disposed inside the power nozzle so that it splits the power stream evenly and fluid exits via the two outlet channels with equal pressures. A shaft upon which the rigid member is mounted is responsive to an external input signal for causing the rigid member to turn so that fluid exits via the two outlet channels with a proportional pressure differential output signal being produced across the outlet channels. A centering spring returns the rigid member to its null position when no external input signal is applied to the shaft.

6 Claims, 1 Drawing Figure



4,245,161

Crowne **Jan. 13, 1981**

[54] **PEIERLS-TRANSITION FAR-INFRARED SOURCE**

[75] Inventor: **Frank J. Crowne,** Greenbelt, Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

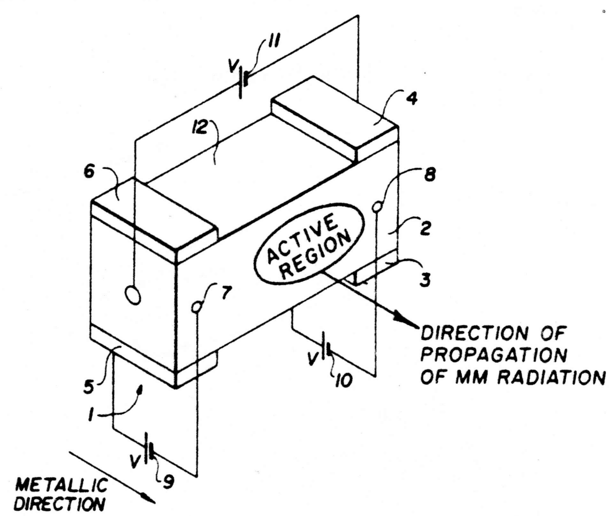
[21] Appl. No.: **84,048**

[22] Filed: **Oct. 12, 1979**

[57] **ABSTRACT**

A Peierls transition far-infrared radiation source comprised of a block of an organic one dimensional metal stressed at the ends and having a potential difference applied.

8 Claims, 3 Drawing Figures



4,246,935

Mon **Jan. 27, 1981**

[54] **TEMPERATURE-COMPENSATED LAMINAR PROPORTIONAL AMPLIFIER**

[75] Inventor: **George Mon,** Silver Spring, Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

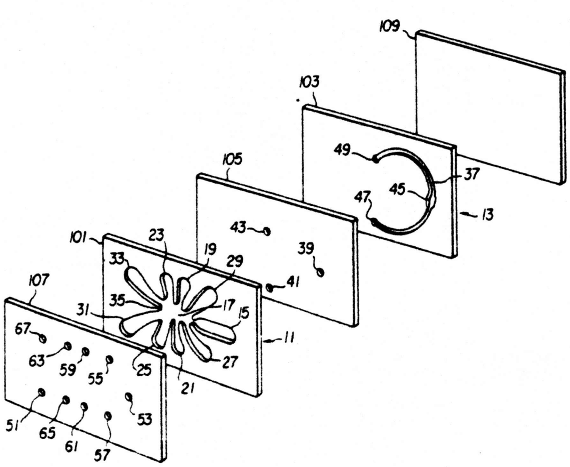
[21] Appl. No.: **14,503**

[22] Filed: **Feb. 23, 1979**

[57] **ABSTRACT**

A temperature-compensated laminar proportional amplifier having an interaction chamber laterally extended into a plurality of vented recesses and a power nozzle for issuing fluid into the interaction chamber. A linear resistor is fluidically coupled between the fluid input of the power nozzle and the fluid outputs of the plurality of vented recesses for bypassing fluid around the power nozzle.

6 Claims, 6 Drawing Figures



4,247,914

Brody **Jan. 27, 1981**

[54] **OPTICAL MEMORY WITH FIBER OPTIC LIGHT GUIDE**

[75] Inventor: **Philip S. Brody,** Brookmont, Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

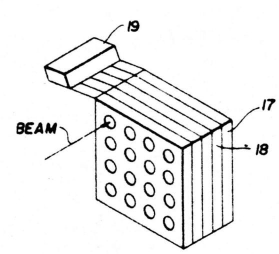
[21] Appl. No.: **47,675**

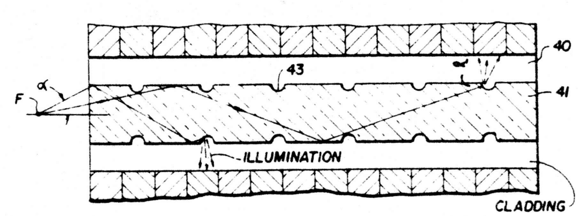
[22] Filed: **Jun. 12, 1979**

[57] **ABSTRACT**

A three dimensional memory having an increased storage capacity. The memory block has a matrix of cylindrical cavities, each of which has a fiber optic light guide means disposed therein. Each light guide means is comprised of a cylindrical core having a first index of refraction and a cladding surrounding the core having a second, smaller index of refraction; a plurality of spaced deformations are formed at the core-cladding interface for allowing light to leak out of the guide laterally.

9 Claims, 8 Drawing Figures





4,250,567

Brody **Feb. 10, 1981**

[54] **PHOTOVOLTAIC-FERROELECTRIC BEAM ACCESSED MEMORY**

[75] Inventor: **Philip S. Brody**, Brookmont, Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, D.C.

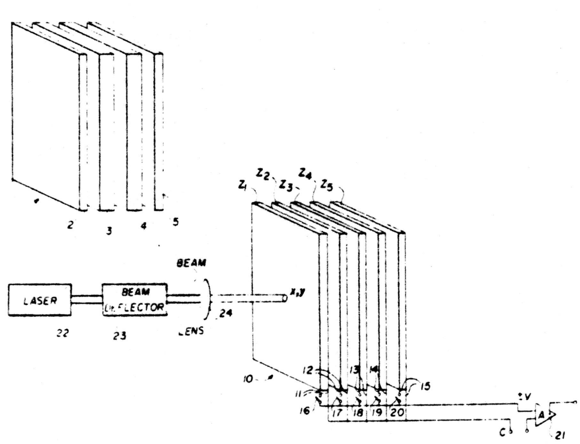
[21] Appl. No.: **50,365**

[22] Filed: **Jun. 20, 1979**

[57] **ABSTRACT**

A three dimensional memory which is comprised of a plurality of stacked memory planes, each of which includes at least a continuous transparent photovoltaic-ferroelectric layer sandwiched between two continuous plane transparent electrodes. In one embodiment, the memory planes are comprised of only the photovoltaic-ferroelectric layer sandwiched between the two electrodes, and in another embodiment the ferroelectric layer and a continuous transparent photoconductive layer are sandwiched between the two electrodes.

15 Claims, 6 Drawing Figures



4,253,495

Mon **Mar. 3, 1981**

[54] **FLUIDIC ELEMENT WITH SUBSTANTIALLY ZERO NULL OFF-SET**

[75] Inventor: **George Mon**, Silver Spring, Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, D.C.

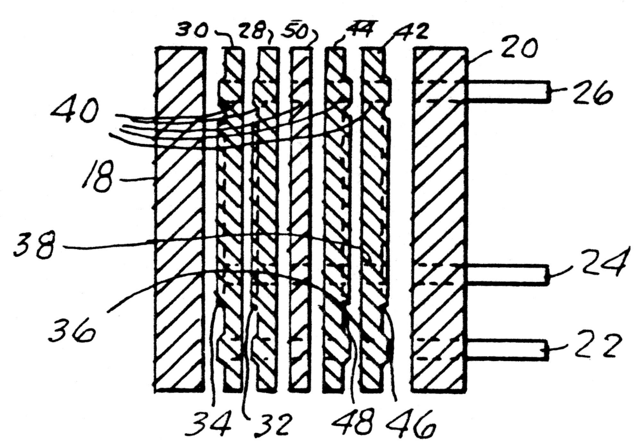
[21] Appl. No.: **930,968**

[22] Filed: **Aug. 4, 1978**

[57] **ABSTRACT**

A fluidic element, such as a laminar proportional amplifier or laminar jet rate sensor, whose null off-set is reduced to substantially zero. A plurality of substantially identical thin laminate plates are stacked between a pair of cover plates. Each of the laminate plates has a passage formed therethrough which is formed by fine blanking that is characterized by formation of a die roll. The die roll has a portion thereof, characterized as a burr, projecting from one side of the plate. A separator plate is positioned between a like number of laminate plates so that the die rolls of each plate on one side of the separator plate face in the opposite direction to that of the die rolls of each of the laminate plates positioned on the other side of the separator plate. The laminate plates and separator plates are all in fluid communication with at least one of the cover plates via aligned supply, control and output conduits.

6 Claims, 8 Drawing Figures



4,256,015

Tippetts et al. **Mar. 17, 1981**

[54] **FLUIDIC STABILIZATION CONTROL**

[75] Inventors: **Thomas B. Tippetts,** Mesa, Ariz.; **Francis M. Manion,** Rockville, Md.

[73] Assignees: **The Garrett Corporation,** Los Angeles, Calif.; **United States of America,** Washington, D.C.

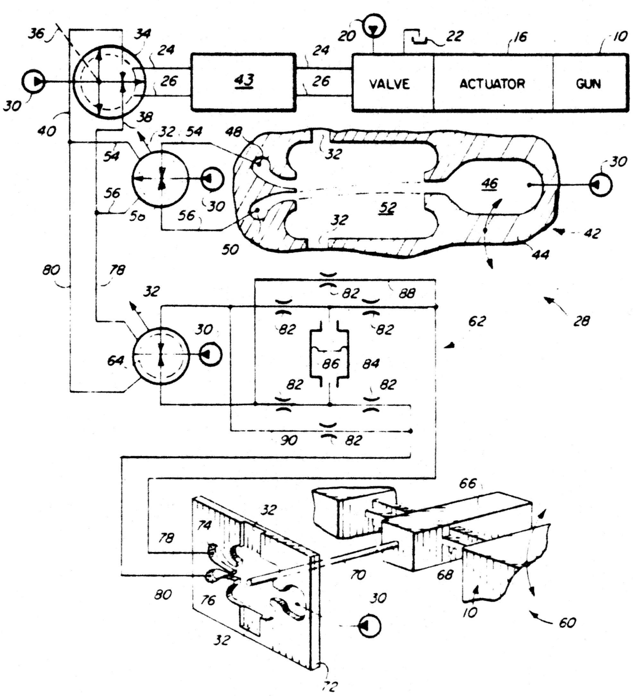
[21] Appl. No.: **967,812**

[22] Filed: **Dec. 8, 1978**

[57] **ABSTRACT**

A fluidic system for stabilizing movement of a body subject to oscillation at its natural frequency, such as a tank-mounted gun, with appropriate circuitry and controls for notch filtering control output signals at the natural frequency.

24 Claims, 2 Drawing Figures



4,259,840

Tenney **Apr. 7, 1981**

[54] **FLUIDIC WASTE GATE**

[75] Inventor: **Stephen M. Tenney,** Rockville, Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

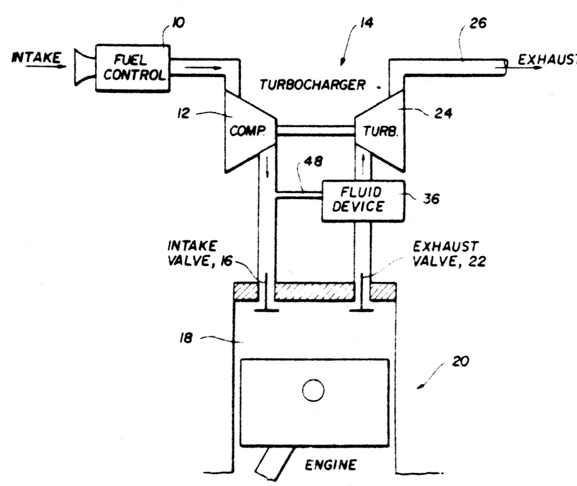
[21] Appl. No.: **87,891**

[22] Filed: **Oct. 24, 1979**

[57] **ABSTRACT**

In the combination of an internal combustion engine, a turbocharger and a waste gate, the improvement is the waste gate which includes a fluidic device having its inlet and outlet connected in parallel with the turbine of the turbocharger and a biasing port responsive to the output of the turbocharger to proportion the fluid flow from the inlet to the outlet between two parallel fluidic paths having a high and low flow resistance respectively. The fluidic device is a fluid amplifier providing radial and tangential flow to a vortex valve to produce the low and high resistance fluidic paths respectively. Alternatively, the fluidic device could be in series with the turbocharger to backpressure the compressor of the turbocharger.

7 Claims, 4 Drawing Figures



4,264,423

Negas et al. **Apr. 28, 1981**

[54] **FLUIDIC THERMISTOR/FUGACITY DEVICE**

[75] Inventors: **Taki Negas,** Ijamsville; **Louis P. Domingues; Tadeusz M. Drzewiecki,** both of Silver Spring; **Richard M. Phillippi,** Highland, all of Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

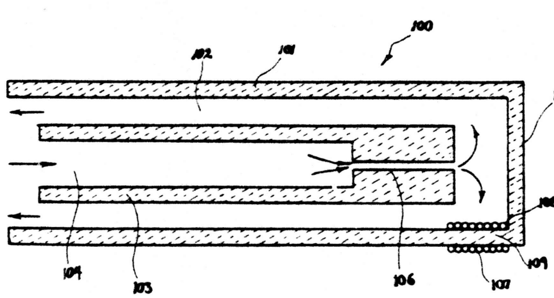
[21] Appl. No.: **76,478**

[22] Filed: **Sep. 17, 1979**

[57] **ABSTRACT**

A device for measuring the fugacity of a material, without requiring a separate device to measure temperature, is disclosed, wherein the device is a solid electrolyte probe, with the probe having a passageway therein, and metallic conductor leads on the outside of the probe and on the inside of the probe in the passageway. The metallic conductor leads are in contact with an E.M.F. measuring circuit, with the reference fluid being passed through the passageway. The passageway also includes a capillary restriction therein, and measuring devices are provided to measure the pressure drop of the reference fluid when flowing through the capillary, thereby permitting determination of temperature. The temperature determination combined with the E.M.F. measurement permit determination of the fugacity of the material.

5 Claims, 4 Drawing Figures



4,271,413

Shreve **Jun. 2, 1981**

[54] **NULL MASK**

[75] Inventor: **James S. Shreve,** Fairfax, Va.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

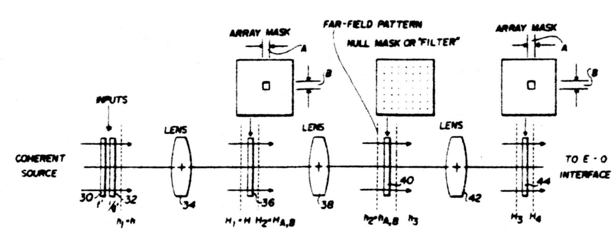
[21] Appl. No.: **47,676**

[22] Filed: **Jun. 12, 1979**

[57] **ABSTRACT**

A coherent optical processor antenna controller which is capable of inserting deep nulls in the antenna pattern at selected locations, without degrading the remainder of the pattern. The processor includes a means for optically forming the far field antenna pattern at a plane and a means for sampling the far field pattern with a matrix of apertures at positions corresponding to the desired positions of the nulls being blocked.

3 Claims, 10 Drawing Figures



4,275,658

Gottron et al. **Jun. 30, 1981**

[54] **SAFING AND ARMING SIGNATURE FOR FUZES**

[75] Inventors: **Richard N. Gottron**, Rockville; **Lyndon S. Cox**, Silver Spring, both of Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, D.C.

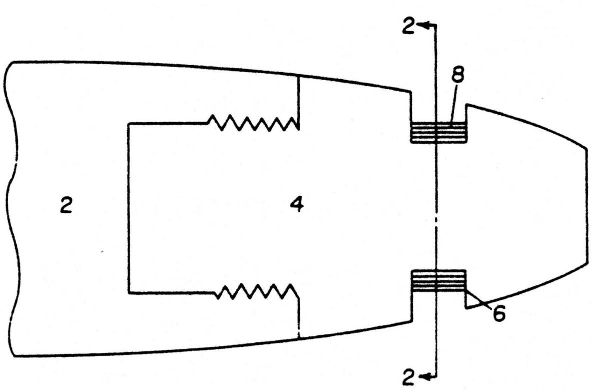
[21] Appl. No.: **84,047**

[22] Filed: **Oct. 12, 1979**

[57] **ABSTRACT**

A recess or cavity is formed on the exterior of a fuze ogive. A piezo-electric tape is positioned within the cavity or recess. Fluctuations in the pressure within the recess, caused by air flow over the exterior of the fuze, will cause the piezo-electric tape to produce an electrical signal or current.

10 Claims, 9 Drawing Figures



4,276,895

Drzewiecki **Jul. 7, 1981**

[54] **APPARATUS AND METHOD FOR TEMPERATURE COMPENSATION OF FLUIDIC CIRCUITS**

[75] Inventor: **Tadeusz M. Drzewiecki**, Silver Spring, Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, D.C.

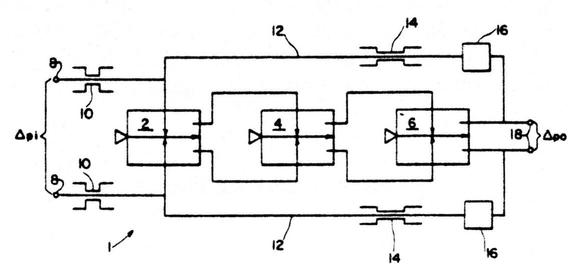
[21] Appl. No.: **77,442**

[22] Filed: **Sep. 20, 1979**

[57] **ABSTRACT**

A temperature compensation device for a fluidic circuit is disclosed. The device comprises a high gain fluid amplifier having input and feedback resistors. The resistance to fluid flow through the input resistor is dependent upon fluid density, while the resistance to flow through the feedback resistor is dependent upon fluid viscosity.

8 Claims, 4 Drawing Figures



4,276,943

Holmes **Jul. 7, 1981**

[54] **FLUIDIC PULSER**

[75] Inventor: **Allen B. Holmes,** Rockville, Md.

[73] Assignee: **The United States of America as represented by the Secretary of the** Army, Washington, D.C.

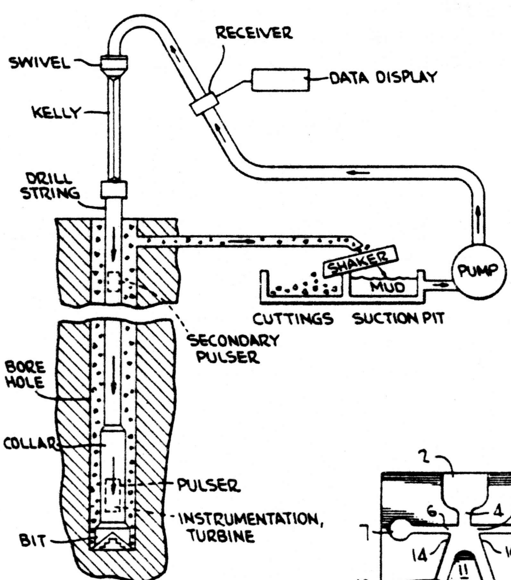
[21] Appl. No.: **78,748**

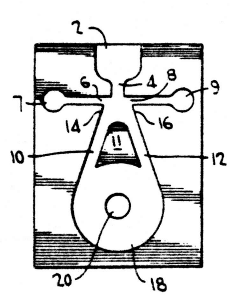
[22] Filed: **Sep. 25, 1979**

[57] **ABSTRACT**

A fluid telemetry system is disclosed which utilizes an improved pulsing device. The pulser comprises a bistable fluid amplifier. Both outlets of the bistable fluid amplifier communicate tangentially with a vortex chamber. A pulse in the fluid entering the amplifier may be produced each time the fluid flow is diverted from one outlet to the other.

8 Claims, 11 Drawing Figures





4,277,019

Shreve **Jul. 7, 1981**

[54] **ELECTRICALLY-CONTROLLED DAMPER**

[76] Inventor: **James S. Shreve,** 10027 Black Ct., Fairfax, Va. 22032

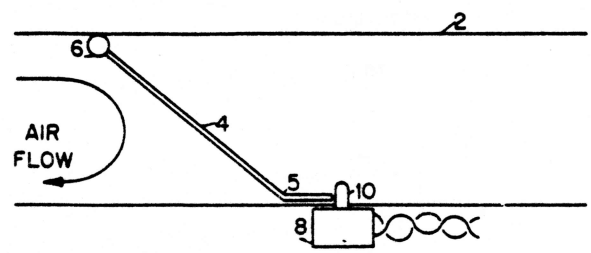
[21] Appl. No.: **148,652**

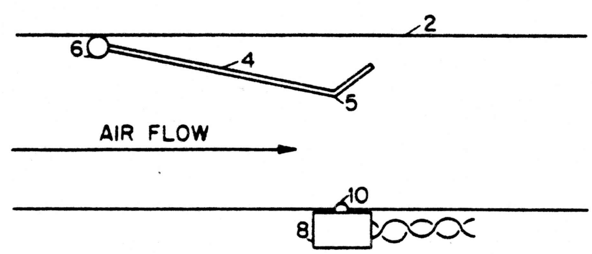
[22] Filed: **May 12, 1980**

[57] **ABSTRACT**

A novel fluid-flow control damper is disclosed. The damper comprises a freely pivotable closure situated in a fluid-flow conduit, such as an air duct. The closure is maintained in a closed position by a simple latching means, and may be maintained in an open condition by means of fluid flow through the conduit. Several of these dampers may be used in combination with a single fluid temperature control device, resulting in a simple, low-cost multizone heating or cooling system.

8 Claims, 13 Drawing Figures





4,277,971

Drzewiecki et al. **Jul. 14, 1981**

[54] FLUIDIC OIL VISCOMETER

[75] Inventors: **Tadeusz M. Drzewiecki,** Silver Spring; **Richard M. Phillippi,** Highland, both of Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

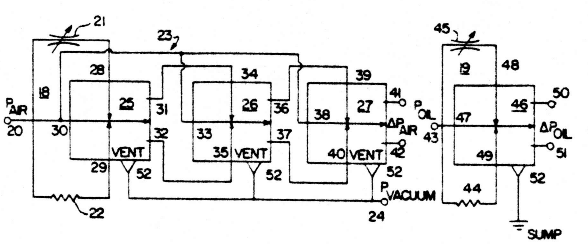
[21] Appl. No.: **110,958**

[22] Filed: **Jan. 10, 1980**

[57] **ABSTRACT**

A fluidic oil viscometer for determining the degradation of machinery lubricating oils compares the viscosity of the machinery oil with the viscosity of another fluid, such as air. Both the viscosity of the air and the viscosity of the oil are sensed, using capillary-orifice combination sensors, and the air viscosity reading is amplified using a series of laminar proportional amplifiers to equalize its change in viscosity with that of oil. The outputs of the capillary orifice combination sensors are applied to two different pressure gauges, the difference between these two pressure gauges represents the viscosity breakdown. This difference will be independent of temperature.

10 Claims, 3 Drawing Figures



4,280,752

Shreve **Jul. 28, 1981**

[54] SOLID-MEDIUM COHERENT OPTICAL PROCESSOR

[75] Inventor: **James S. Shreve,** Fairfax, Va.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

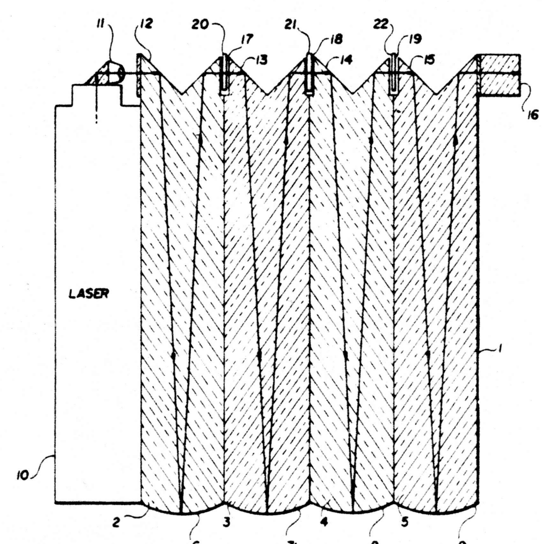
[21] Appl. No.: **19,031**

[22] Filed: **Mar. 9, 1979**

[57] **ABSTRACT**

A coherent optical processor device comprised of a monolithic mass of transparent optical material. The device is built up of a plurality of modules, each having a curved reflective surface for performing a Fourier transform operation and a V-shaped reflective surface, for reflecting the beam and directing it to the next module. Plates or masks for changing the amplitude and/or phase of the beam may be inserted in air gaps between contiguous modules. The device provides absolute path length constancy, is not vulnerable to the adverse effects of dust, and minimizes the multiple reflections ordinarily produced at air-glass interfaces.

2 Claims, 1 Drawing Figure



4,281,601

Overman **Aug. 4, 1981**

[54] **NON-SLIP TURNING JOINT FOR FUZES**

[75] Inventor: **David L. Overman,** Silver Spring, Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

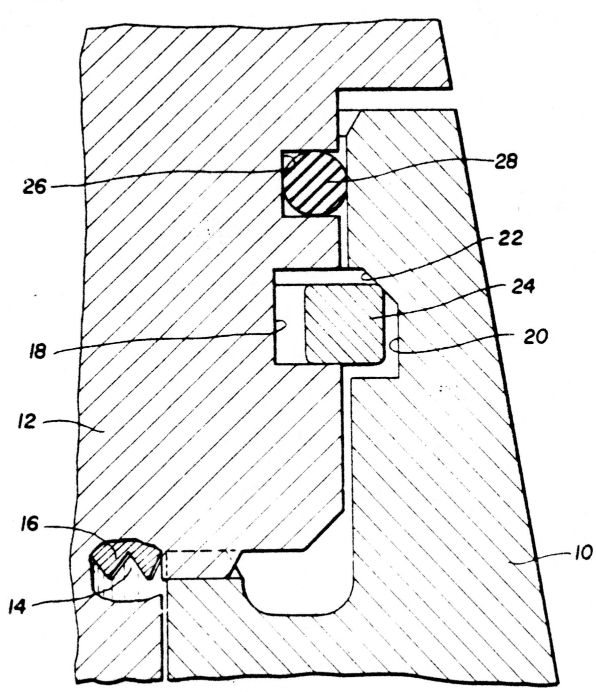
[21] Appl. No.: **57,873**

[22] Filed: **Jul. 16, 1979**

[57] **ABSTRACT**

Relative rotation of the two rotational members of a fuze during dynamic condition of firing are eliminated by interlocking annular, serrated, axial seating surfaces of the two members. A radially sinusoidal split ring in between radially adjacent annular recesses of the members cooperates with an inclined wall of the outer member's annular recess to provide an axial force biasing the serrated surfaces into engagement during static conditions. The split ring further serves as a locking device to hold the two members together as an assembly.

7 Claims, 3 Drawing Figures



4,284,862

Overman et al. **Aug. 18, 1981**

[54] **ACCELERATION SWITCH**

[75] Inventors: **David L. Overman; Robert N. Johnson,** both of Silver Spring, Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

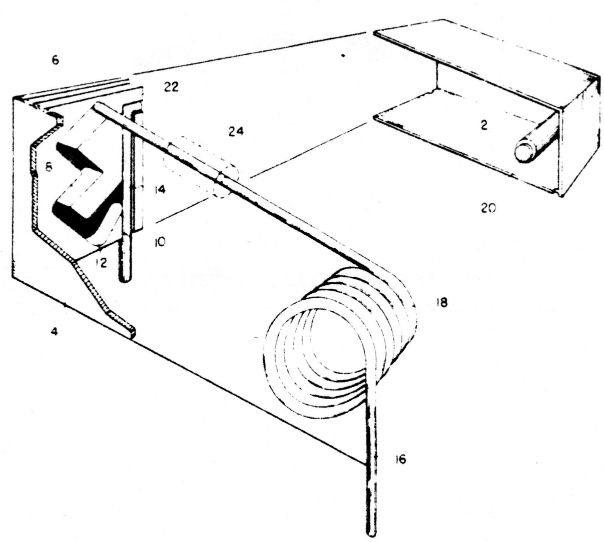
[21] Appl. No.: **132,205**

[22] Filed: **Mar. 20, 1980**

[57] **ABSTRACT**

An acceleration actuated switch is disclosed which is capable of distinguishing between random and brief acceleration forces on the one hand and sustained acceleration forces on the other hand. The device comprises a stationary electrical contact and a movable contact held in position by biasing means. Sustained acceleration forces in a particular direction will drive the movable contact along a fixed path to a position whereat the biasing means may bring the movable contact into proximity with the stationary contact thereby closing the switch. If the acceleration force is not in the proper direction or is not applied to the switch for a sufficient length of time, the biasing means will return the movable contact to its original position thereby maintaining the switch in an open condition.

9 Claims, 5 Drawing Figures



4,286,230

Morrison et al. — Aug. 25, 1981

[54] **NEAR MILLIMETER WAVE GENERATOR WITH DIELECTRIC CAVITY**

[75] Inventors: **Clyde A. Morrison**, Wheaton; **Donald E. Wortman**, Rockville; **Richard P. Leavitt**, Berwyn Heights; **Nick Karayianis**, Rockville, all of Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, D.C.

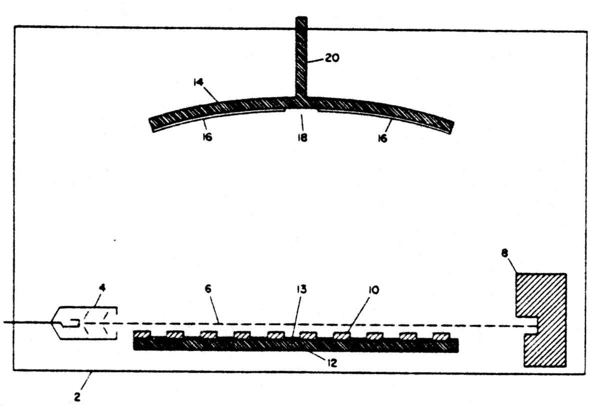
[21] Appl. No.: **110,955**

[22] Filed: **Jan. 10, 1980**

[57] **ABSTRACT**

A high frequency electromagnetic wave generator is disclosed which comprises an electron gun which directs an electron beam through a region generally adjacent a diffraction grating. The grating cooperates with an opposed reflecting surface to produce a standing electromagnetic wave. The reflector comprises a highly reflective dielectric coated mirror. Supporting means for the diffraction grating may also comprise a reflective dielectric surface.

8 Claims, 1 Drawing Figure



4,291,395

Holmes — Sep. 22, 1981

[54] **FLUID OSCILLATOR**

[75] Inventor: **Allen B. Holmes**, Rockville, Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, D.C.

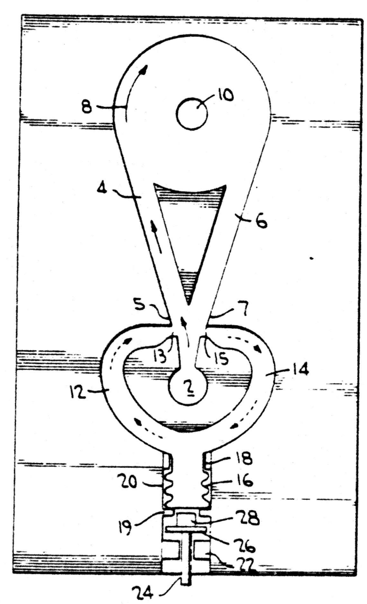
[21] Appl. No.: **64,451**

[22] Filed: **Aug. 7, 1979**

[57] **ABSTRACT**

A telemetry system is disclosed which utilizes a fluid feedback oscillator in conjunction with a flow restricting device in order to generate pulses in a fluid. Means are provided to turn the oscillator on or off or to vary the frequency of oscillation, thereby permitting the transmission of information by means of the fluid pulses.

6 Claims, 4 Drawing Figures



patent applications

Application title	Serial No.	Filing date	Inventor(s)
Heterodyne Indicial Refractometer	194,736	7 Oct 80	Joseph P. Stattler Terrance L. Worchesky Kenneth J. Ritter
A Dual Channel Correlator for an FM-CW Ranging Radar	196,409	14 Oct 80	Ross A. Parkhurst David L. Rodkey John O. Wedel
Selectable-Mode Microstrip Antenna and Selectable-Mode Microstrip Antenna Arrays	198,673	20 Oct 80	Frederick G. Farrar Daniel H. Schaubert
A Lighter than Air Wind Energy Conversion System	200,104	24 Oct 80	William R. Benoit
A Lighter than Air Wind Energy Conversion System Utilizing an Internal Radial Disk Diffuser	200,103	24 Oct 80	William R. Benoit
A Lighter than Air Wind Energy Conversion System Utilizing a Rearwardly Mounted Internal Radial Disk Diffuser	200,106	24 Oct 80	William R. Benoit
A Lighter than Air Wind Energy Conversion System Utilizing an External Radial Disk Diffuser	200,105	24 Oct 80	William R. Benoit
System and Method for Testing the Reaction of Rare Earth Ions	200,832	28 Oct 80	Clyde A. Morrison Joseph P. Sattler
High Speed Rectangle Function Generator	216,232	15 Dec 80	Dieter R. Lohrmann

patent applications

Application title	Serial No.	Filing date	Inventor(s)
Fluidic-Controlled Oxygen Intermittent Demand Flow Device	217,881	18 Dec 80	George Mon
Non-Volatile Semiconductor Memory	230,177	30 Jan 81	Philip S. Brody
Acousto-Optic Time Integrating Frequency Scanning Correlator	251,605	6 Apr 81	Norman J. Berg Irwin J. Abramovitz Michael W. Casseday John N. Lee
Source-Region Electromagnetic Pulse Simulator	252,737	10 Apr 81	George Merkel William D. Scharf
Superlattice Millimeter Wave Detector	256,356	22 Apr 81	Frank J. Crowne George J. Simonis Bruce A. Weber
Dual Pulse Doppler Radar System	262,876	29 Apr 81	John M. David
Self-Survey Means	258,828	29 Apr 81	James S. Shreve
Fluidic Valve and Pulsing Device	273,170	12 Jun 81	Allen B. Holmes
EM Sensor for Determining Impedance of EM Field	275,470	19 Jun 81	Andrew A. Cuneo, Jr. James J. Loftus
Test Set for Transient Protection Devices	277,306	25 Jun 81	John E. B. Tuttle
Coherent Optical Source	277,424	25 Jun 81	Joseph Nemarich George J. Simonis
High Speed PIN Diode Switch	283,317	14 Jul 81	Alford L. Ward
Electrically-Controlled Damper	279,387	1 Jul 81	James S. Shreve
Radiation Hardened MOS Devices and Method for Producing the Same	283,255	14 Jul 81	James M. McGarrity
Microstrip Antenna with Polarization Diversity	292,101	11 Aug 81	Daniel H. Schaubert Frederick G. Farrar